THE NEW WARN SHEET METAL WORKER.

THE SHEET METAL WORKER'S INSTRUCTOR,

FOR

ZINC, SHEET IRON, COPPER, AND TIN PLATE WORKERS, AND OTHERS:

CONTAINING A

SELECTION OF GEOMETRICAL PROBLEMS,

ALSO

PRACTICAL AND SIMPLE RULES FOR DESCRIBING THE VARIOUS PATTERNS REQUIRED IN THE DIFFERENT BRANCHES OF THE ABOVE TRADES.

BY

REUBEN HENRY WARN,

PRACTICAL TIN PLATE WORKER.

TO WHICH IS ADDED

AN APPENDIX

CONTAINING

INSTRUCTIONS FOR BOILER MAKING, MENSURATION OF SURFACES AND SOLIDS, RULES FOR CALCULATING THE WEIGHTS OF DIFFERENT FIGURES OF IRON AND STEEL, TABLES OF THE WEIGHTS OF IRON, STEEL, ETC.

ILLUSTRATED BY THIRTY-TWO PLATES AND NINETY-SEVEN ADDITIONAL ENGRAVINGS.

A NEW AND ENLARGED EDITION

TO WHICH ARE ADDED

SHEET METAL WORK PROCESSES, INCLUDING TOOLS, JOINTS, SOLDERS, FLUXES, ETC.; AS WELL AS GEOMETRY APPLIED TO SHEET METAL WORK.

PHILADELPHIA:
HENRY CAREY BAIRD & CO.,
INDUSTRIAL PUBLISHERS, BOOKSELLERS AND IMPORTERS,
810 WALNUT STREET.
1906.

PUBLISHER'S PREFACE TO THE SIXTH EDITION, REVISED.

WARN'S SHEET METAL WORKER'S INSTRUCTOR having been well tried and well proved, still enjoying great popularity and being in active demand, and a new edition being called for, the publishers, with a view to increasing its usefulness have caused to be added to it considerable matter of great practical value. This matter comprises, Sheet Metal Work Processes, such as Sheet Metal Working, Tools, and Manipulation, Joints, Galvanized Iron, Soldering and Solders, both Hard and Soft, Fluxes, Modes of applying Heat, Brazing, and Geometry as applied to Sheet Metal Work; this latter being illustrated by thirty-one engravings.

The book has of course been supplied with a good Table of Contents, and a full Index, thus

rendering any subject prompt and easy of reference.

In its present form it is believed that it will find new popularity and new uses, and that its future sale will even rival that of the past, great as that has been.

PHILADELPHIA, *February* 22, 1906.

INTRODUCTION.

THIS Work is intended as a book for private study for artisans in the various branches of the Sheet Metal Trade.

The first four plates contain a selection of Problems on Practical Geometry, which embrace principles in the above trades, and which it is hoped will serve as an introduction to the accompanying diagrams, enabling the student more readily to work out the several figures. Indeed, Geometry is of great service to working mechanics, both when called upon to work from drawn plans, and when required (as is frequently the case) either to alter some device, or to form an original pattern; nor is it less serviceable when instructing apprentices in their respective arts.

In selecting the subjects contained in the plates, the aim has been to place them in such easy stages of advancement, that the figures may be easily worked, and so that the earlier diagrams may assist the student both in comprehending and in working out those which follow.

The student is recommended not merely to read the letterpress, but to take a pair of compasses, with shifting leg for pencil, a T and set squares, a square board, and some paper, and work out every figure in the book, for it is only in this way that he can hope to obtain a proper knowledge of the various diagrams herein contained. By working out carefully each figure, the mind will embrace the principles contained therein, and the figures themselves will be thereby better fastened on the memory; and further, the student by this means will derive increasing pleasure as he proceeds from figure to

figure. Some students will find it beneficial to work the figures through in this manner several times.

If any reader should think the description of the diagrams too diffuse, or even commonplace, the answer must be that the Author desires the work to be useful, not only to the most cultured of his fellow-workmen, but also to apprentices, and to such adults as may have had only a very limited education: and further, as the words used in one trade are often almost intelligible to others, such language has been used throughout as will, perhaps, be on the whole most readily understood.

While the Author disclaims entire originality for the whole of this course of instruction, yet there are many portions thereof which he has never seen elsewhere, and believes to be original.

And as, in the few years the Author has turned his attention to the subject, he has found considerable pleasure and benefit therefrom, he hopes that his fellow-workmen who use this book will derive equal or even greater pleasure and benefit from its study; and if so he will feel great satisfaction in the effort herein bestowed.

R. H. WARN.

CONTENTS.

A SELECTION OF GEOMETRICAL PROBLEMS.

SHEET METAL WORK PROCESSES.

I.

SHEET METAL WORKING.

PAGE

II.

SOLDERING.

III.

GEOMETRY AS APPLIED TO SHEET METAL WORKING.

APPENDIX.

RULES FOR BOILER-MAKING, ETC.

PAGE

MENSURATION OF SURFACES.

APPROXIMATE RULES FOR FINDING THE WEIGHT OF DIFFERENT FIGURES OF WROUGHT IRON AND STEEL.

SIZES OF TINWARE IN FORM OF FRUSTUM OF A CONE.

THE

SHEET METAL WORKER'S INSTRUCTOR.

PLATE I.

Fig. 1.—To draw a straight line parallel[1] to a given line, and at a given distance from it.

Let AB be the given straight line, and the line AC to represent the distance between the parallels.

Then with A as a centre, with the radius AC describe the arcs[2] (or curves) C and D. Draw the line CD so as to touch these curves, and CD will be parallel to AB as required.

Fig. 2.—To bisect a given straight line; that is, to divide it into two equal parts at right angles.

Let AB be the given line. From any part, say *o o*, with radius[3] greater than half the length *o o*, describe curves cutting each other in CD. Then a straight line drawn through the points of intersection[4] will bisect the line AB.

2

Fig. 3.—To divide a given line into any number of equal parts (in this case seven).

Let AB be the given line which is to be divided into seven equal parts. From the point A draw another line (not being particular as to what angle with AB), and with any convenient opening of the compasses set off seven equal parts, as 1, 2, 3, 4, 5, 6, 7. Join the points 7 and B, and draw parallel lines from 6, 5, 4, 3, 2, 1, to cut the line AB, which will be divided into seven equal parts as required.

Fig. 4.—To draw a straight line equal to the circumference of a given circle.

Let ADBC be the given circle. Draw the diameter AB, and from its centre *o* draw the perpendicular CD. Draw a diagonal line AC; set the compasses in C, and with a radius at any distance beyond its centre *a* describe the arc E; now with the compass in A draw another arc intersecting at E, and draw the line *o* E, then three times the diameter, with the distance *a b* added, will be a close approximation to the length of the circumference.

Fig. 5 is the same, but showing only the section required.

Fig. 6.—To construct a plain scale, for

Plate. 1.

Fig. 1.

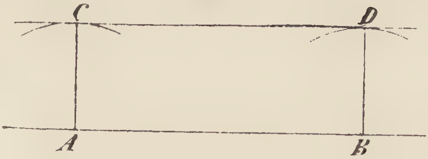


Fig 2

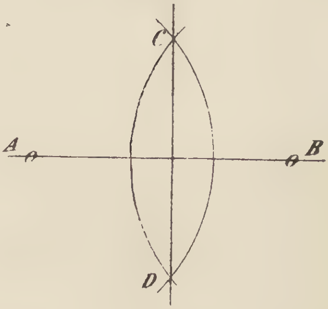


Fig. 3

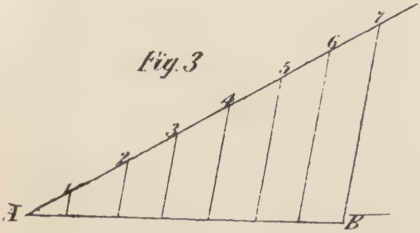


Fig. 4

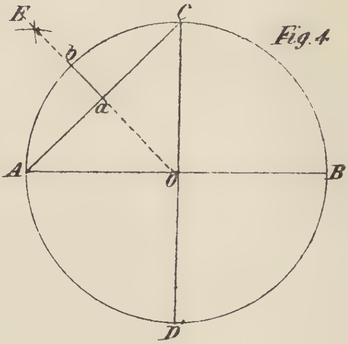


Fig. 5

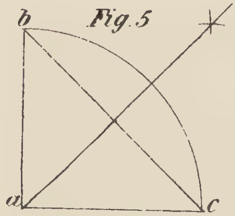


Fig. 6.

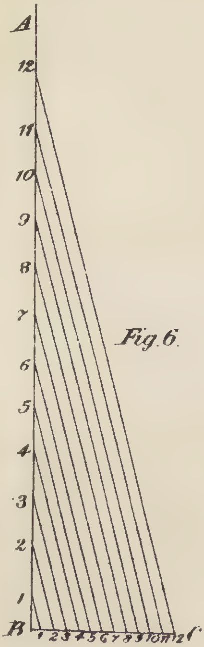


Fig. 7.

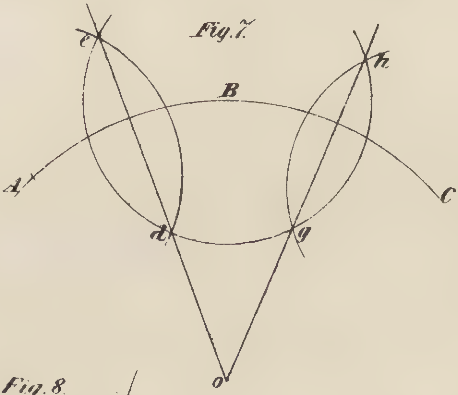


Fig. 8.

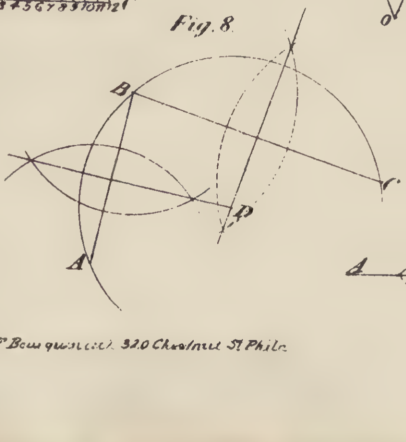
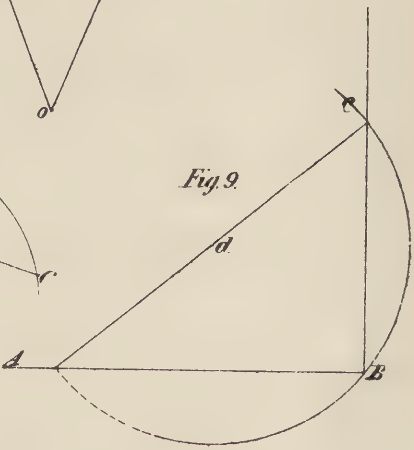


Fig. 9.



F. Bourquin sc. 320 Chestnut St. Phila.

drawing a small plan proportionate to a larger one.

Draw a line AB, say 12 inches long, and mark off the inches as from 1 to 12; then draw BC, say 2 inches long. Draw a line from 12 to C, and draw parallel lines from the points 11, 10, 9, 8, etc., to cut the line BC. By using the distances on the line BC, as 1, 2, 3, 4, etc., as inches, you would get a scale of 2 inches to the foot.

FIG. 7.—To find the centre of a circle or the radius of a curve.

From the point B as a centre, with radius greater than half the distance to the other points, draw a portion of a circle, as *e d g h*, and from A and C as centres, with the same radii, draw curves to intersect or cut the part of a circle first drawn at *e d* and *g h*. From these points of intersection draw lines *e d* and *g h* until they meet at *o*, which will be the centre of the curve required.

FIG. 8.—To draw a circle through any three given points (provided they are not in a direct line).

Let ABC be the three given points; join AB and BC; bisect AB and BC, and produce the bisecting lines until they cut each other in the point D, then D will be equi-distant from

each of the three points, and the centre of the circle required.

Fig. 9.—From the point B on the line AB to erect a perpendicular.[5]

Above the given line AB take any point *d*, and with the radius *d* B draw a portion of a circle ABC. Draw a line from points A *d* to meet the circle in C. Draw the line BC, which will be perpendicular to AB.

NOTES.

[1] A parallel line is one that runs in the same direction as another line, but always keeps at the same distance from it.

[2] Arc is part of a circle. The word "curve" will be used frequently in the commencement instead of arc; but it should be remembered that a curve is not always part of a circle.

[3] A circle is a figure bounded by a curve equally distant in every part from its centre. A straight line across the figure through the centre is called its diameter, half this line is the radius, it being the length from the centre of a circle to its outer line or circumference.

[4] Where one line or curve crosses or cuts through another, is called the point of intersection.

[5] Perpendicular means square with another line. To say that a line is perpendicular does not necessarily mean that it is upright, but at right angles or perpendicular to the line on which it is drawn. When two lines are perpendicular to each other they form a right angle. A line formed by a cord having a weight at its end is really an upright line or a vertical line.

PLATE II.

Fig. 1.—To strike a segment (or part of a circle) by a triangular guide, the chord[1] and height being given.

Let AB be the chord of the segment and DC the height (or versed sine); join BC and cut CE parallel to AB, and make it equal BC, fix a pin in B and another in C, and with the triangle ECB describe the curve CB, then remove the pin B to A, and by guiding the sides of the triangle against AC, strike the other part of the curve ACB.

Fig. 2.—The chord and height of a segment of a circle of large radius being given, to find the curve without having recourse to the centre, which is supposed to be unattainable.

Let AC be the chord line and DB the height, through B draw EF parallel to AC, join AB and BC, draw AE at right angles to AB, and CF at right angles to BC, divide AD and EB into any number of equal parts (say 6), join the corresponding numbers 1 1, 2 2, 3 3, &c. Also divide AG into the same number of equal parts, and from each division draw lines to B, and the points of intersection will be points in the curves.

Fig. 3.—Having an arc of a circle given, to raise perpendiculars from any point or points without finding the centre.

Let AB be the given curve or arc, and A 1 2 3 4 5 the points from which perpendiculars are to be erected, in the space 5B make the point 6 equal to 4 5, from 4 and 6 as centres, with a radii greater than half the distance between them describe arcs intersecting each other at 7, a line drawn at the point of intersection at 7 to 5 gives one of the perpendiculars required, the other points as far as 11 will be found in the same manner. If a perpendicular is to be raised at A, the extremity of the curve, a method somewhat different must be employed; suppose the perpendicular 1 11 to be erected, from 1 with the radius 1 A describe the curve A 11, and from A with the same distance describe 12 1, make *o* 12 equal *o* 11 and join A 12, will give the perpendicular wanted.

Note.—The A should be exactly under the line 12, it has been drawn too far in error.

Fig. 4.—To draw a tangent[2] to a circle or portion of a circle without having recourse to the centre.

Let A be the point from which the tangent is to be drawn, take any other point in the circle AC, join AC and bisect the curve AC at

Plate. 2.

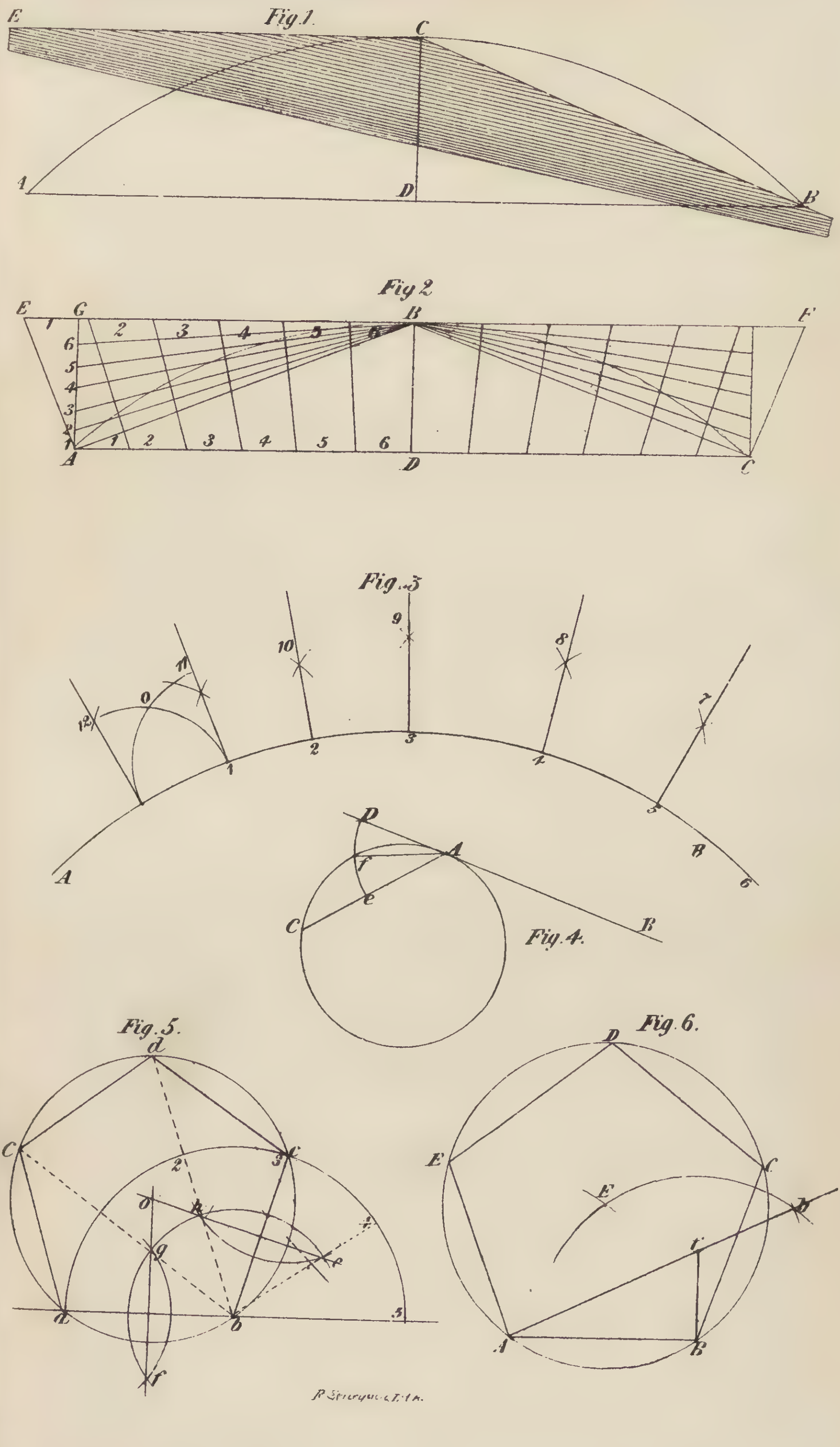


Fig. 1.
E
C
A
D
B
Fig 2
E
G
B
F
A
D
C
Fig. 3
A
B
Fig. 4.
D
A
f
e
C
B
Fig. 5.
d
c
o
g
h
e
a
b
f
Fig. 6.
D
E
C
t
A
B

f, then from A as centre with a radius A*f*, the chord of half the curve, describe the curve *ef* D, making *f* D equal *ef*, then through the points AD draw the line DAB, which will be the tangent required.

Fig. 5.—Upon a given straight line to describe any regular polygon (in this case a pentagon).

Produce *ab* indefinitely,[3] from *b* as centre with a radius *b a*, describe the semicircle *a c* 5, which divide into as many equal parts as there are to be sides in the polygon, which in the present example is five, through the second division from 5 draw the line *b c*, which will form another side, bisect these sides as shown at *f g h e*, the point of intersection at *o* is the centre of the circle of which *a b c* are points in the circumference, then by producing the dotted lines *b* 1 to *c*, and *b* 2 to *d*, will divide the circle into the number of parts required.

Fig. 6.—Upon a given side to draw a regular pentagon.

Let AB be the given side, from its extremity B erect a perpendicular B*f* equal to half AB, join A*f* and produce it till *f b* be equal to B*f*, from A and B as centres with a radius equal to B*b*, draw arcs intersecting at E, which will

be the centre of a circle containing five divisions equal to AB.

NOTES.

[1] Chord, a line cutting off any part of a circle. The part of a circle thus cut off or divided by a chord is called a segment.

[2] Tangent, a line perpendicular to a radius, that is to say, a line required to be drawn from a curve or a circle without any perceptible point where it joins the curve; the line should be at right angles with the centre that the curve was struck by, the line will then be tangent.

[3] To produce a line, or draw a line indefinitely, is to carry it further or make longer in the same direction; its required length is sometimes not known until intersected by another line.

PLATE III.

FIG. 1.—Upon a given side to draw a hexagon.

Suppose AB to be the given side, from the extremities A and B draw curves intersecting at G; from G with a radius GA describe the circle ABCDEF, which will contain six divisions equal to AB.

FIG. 2 is drawn precisely the same.

By drawing the lines ABC to the centre D,

Plate 3.

Fig ..

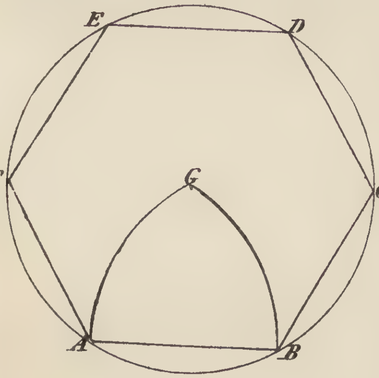


Fig 2

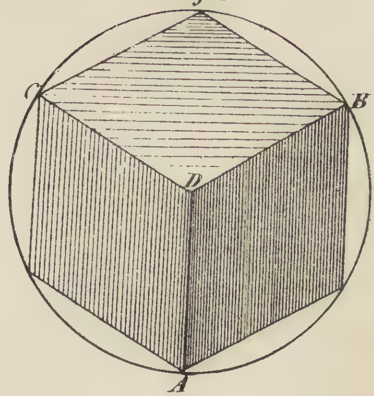


Fig. 3.

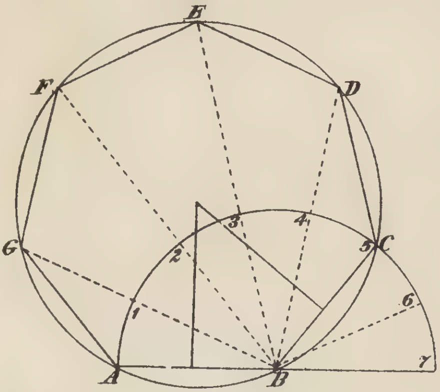


Fig. 4

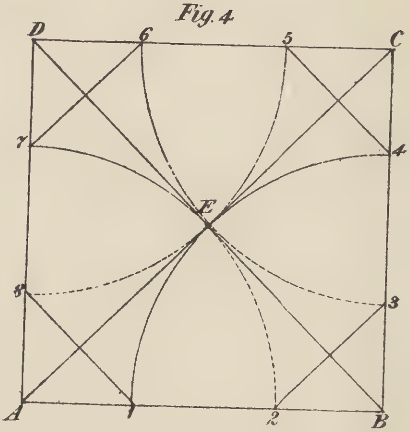


Fig. 5.

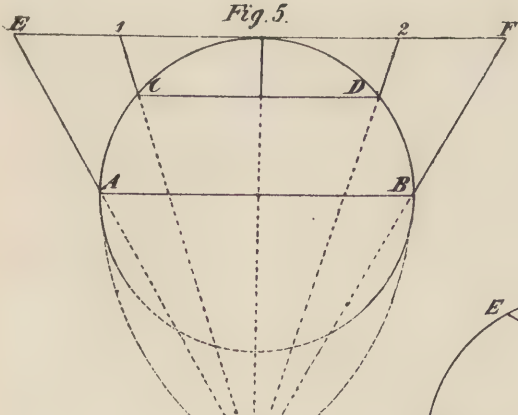
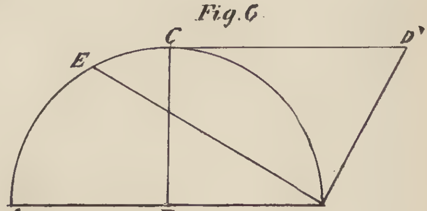


Fig. 6



F. Bourquin Lith.

the vertical and horizontal projections of a cube are given, with the plan and elevation in one view.

FIG. 3 is a heptagon drawn on the same principle as the pentagon, Fig. 5, Plate II., and which will give a sufficient explanation how this or any other polygon having a given number of equal sides is drawn.

FIG. 4 shows how to describe an octagon in a given square.

Let ABCD be the given square. Draw the diagonals ACDB, then from the angular points ABC and D, with a radius equal to AE, describe curves cutting the sides of the square in 1 2 3 4 5 6 7 8, then by joining these points the polygon will be complete.

FIG. 5.—To draw a straight line equal to any given part of a circle.

Let AB or CD be the given arcs. From A with radius AB, and vice versa, describe arcs intersecting at G. Draw EF parallel to AB, then from G draw lines through A and B cutting at E and F, then EF in the length of the curve from A to B.

Again, draw lines from G, through C and D, cutting at 1 and 2 will give the stretch-out from C to D. On the same principle the

stretch-out may be found from any other point in the semicircle.

FIG. 6.—To find the stretch-out of a semicircle by another method.

Let ACB be the semicircle. Make AE equal AF, and draw EB, then draw BD at right angles to EB, and draw CD parallel to AB; CD is the length of the quadrant CB, and twice CD the length of the semicircle ACB.

Definition of Polygons.

All figures having more than four sides are called polygons, and are distinguished by names denoting the number of their sides, thus:—

A Polygon of	five sides	is called a	Pentagon.
"	six	"	Hexagon.
"	seven	"	Heptagon.
"	eight	"	Octagon.
"	nine	"	Nonagon.
"	ten	"	Decagon.
"	eleven	"	Undecagon.
"	twelve	"	Duodecagon.

When all the sides of a polygon are equal and all its angles equal, it is called "regular." When they are not equal, the polygon is called "irregular."

Definition of four-sided figures, or Parallelograms.

A parallelogram is a four-sided figure whose opposite sides are parallel to each other. When the four sides are equal and the four angles are right angles the figure is called a square, as shown by Fig. 4 (Plate III) ABCD

Diagonals are lines crossing to opposite angles, as AC and DB.

When one pair of sides is of a different length to the other, but the sides remain parallel to each other in opposite pairs, the angles being right angles, the figure is called a rectangle or parallelogram, such as the four right lines within which an oval is described (Fig. 2, Plate IV). When the four sides are equal and the opposite sides parallel to each other, but the angles not right angles, the figure is called a rhombus or lozenge, a figure frequently known as a diamond shape (see Fig. 7, Plate II).

An angle is an opening formed by any two lines meeting at a point. If this opening be greater than that formed by a line meeting perpendicularly, it is called an obtuse angle. If the opening be less than one formed by a perpendicular line, it is called an acute angle.

Triangles.—In a right-angle triangle, one of the angles is a right angle or square, as in Fig. 9, Plate I. A triangle having all three sides and angles alike, is called an equilateral triangle.

PLATE IV.

Fig. 1.—To strike an ellipse (or oval) with the compasses, the length or major axis being given.

Divide the given length 1 5 into five equal parts, then with 2 as the centre and a radius 2 4, and vice versa, describe curves intersecting at A and B; then from the points A and B draw lines through 2 and 4 indefinitely, with 2 as centre and radius 2 1, describe the curve CD, and from 4 the curve EF; now with centre A and radius AD, describe the curve DF, and from B the curve CE, which completes the ellipse.

Fig. 2.—To describe an ellipse within a given square, or when the major and minor axes are given.

Draw the major axis AB, and minor axis C D, make the diagonal BD, take the distance AE on the major axis, and transfer from B to 1 on the diagonal BD, also the distance ED to the point 3; take half 1 3 in the point 2 as centre, and any distance towards B greater than its half, and vice versa; from B describe arcs intersecting at 4 and 5, through these points draw a line until it cuts the minor axis at C, make E*g* equal E*o*, and ED equal EC, from C and D draw lines through *o* and *g* indefinitely, then with centre *g* and radius *g*A, describe the curve 6A8, and from centre *o*, 5B7; then from centre C and radius CD, draw the curve 8D5, and centre D the curve 6C7, which will complete the ellipse.

Plate. 4.

Fig. 1.

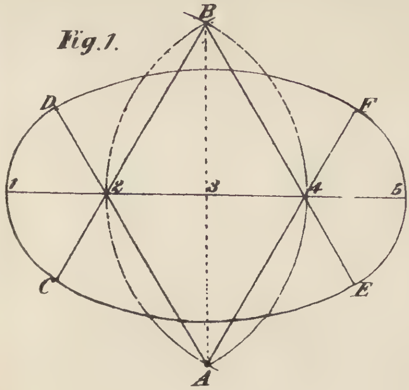


Fig. 2.

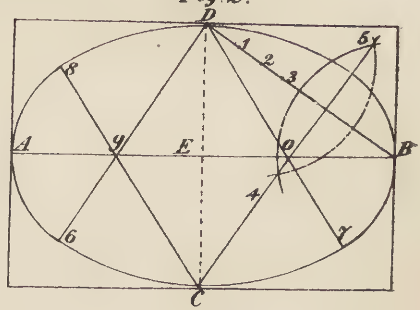


Fig. 3.

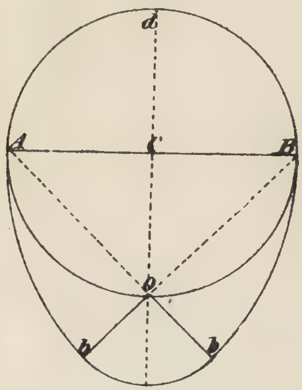
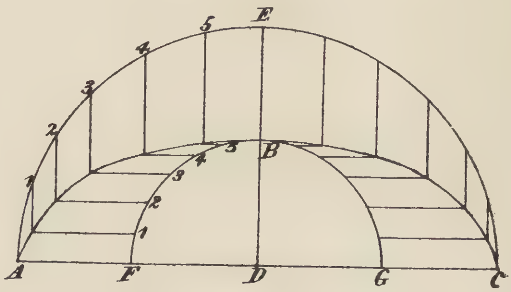


Fig. 4.



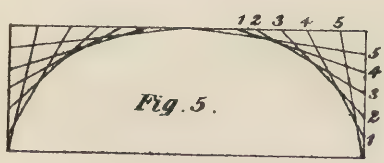


Fig. 5.

Fig. 6.

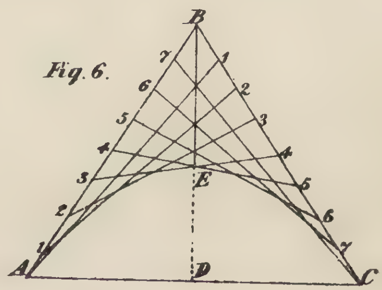
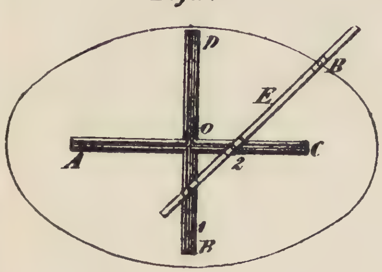


Fig. 7.



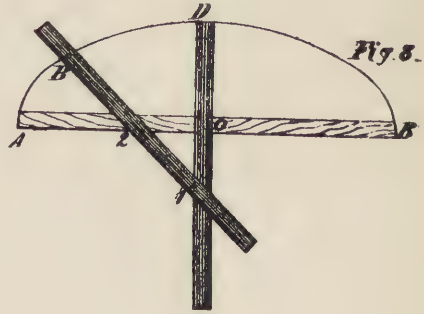


Fig. 8.

Fig. 3 shows a method of drawing an egg-shaped oval.

Draw the line AB, and bisect it in C; with centre C draw circle A *o* B *d*, and draw the diagonals A *o b* and B *o b*, then with A as centre, and radius AB, draw the curve B *b*, and with centre B the curve A *b*; now with *o* for centre, and radius *o b*, describe the curve *b b*, which makes the oval required.

Fig. 4.—If two semicircles are described as shown in this figure, and both semicircles divided into the same number of equal parts, and if through the points of division of the larger semicircle lines are drawn perpendicular to AC, and through the corresponding points in the smaller one parallel to AC, the points of intersection will be points in the elliptic curve, giving a graphic illustration of what an ellipse really is.

Fig. 5 is another method of drawing an ellipse by intersecting lines, so simple in construction as to need no further explanation.

Fig. 6.—To draw a parabola by the intersection of lines, its axis, height, and base or ordinate being given.

Let AC be the base, and DE the axis, and E its vertex; produce the axis to B and make EB equal DE, join AB, CB, and divide them

into the same number of equal parts, join the divisions by the lines 1 1, 2 2, &c., and their intersections will produce the curve required.

Fig. 7.—To draw an ellipse with the trammel. The trammel is an instrument consisting of a right-angled cross ABCD grooved on one side, and a tracer E with three movable studs 1,2,B, two of which slide in the grooves just mentioned, the other at B is provided with a pencil to trace the curve of the ellipse. For the application suppose AC to be the major axis, and BD the minor; lay the cross of the trammel on these lines; then adjust the sliders of the tracer so that 1 B may be equal to *o* C, and 2 B equal *o* D; then by sliding the tracer in the grooves of the cross, the pencil at B will describe the ellipse.

Fig. 8.—This is precisely the same principle of drawing the ellipse as Fig. 7, and is inserted because the trammel (which is perhaps preferable to any other method of drawing this curve) is not always at hand; and this is a trammel easily constructed and answers every purpose. Take A to *o* as the major axis, and D to *o* as the minor, on which another straight-edge is to be fastened and extended as shown; put a bradawl or nail through at 1 and 2, and apply the pencil at B, then by sliding the tracer

round, keeping the bradawls against the axes of the ellipse, one quarter of the curve will be described; now move the tracer to another quarter, and describe it in the same manner, and continue in like manner until the ellipse is completed.

NOTES.

Fig. 3 (Plate IV.) represents an oval, which is egg-like (from *ova*, an egg); but according to the custom of many trades Figs. 1 and 2, and Fig. 8 in Plate V. are commonly accepted as ovals, although strictly they are ellipses, or methods of describing an ellipse with the compasses by means of arcs of circles, practically good and useful.

Figs. 4, 5, 7, 8 show various methods employed to obtain perfect ellipses under the following definitions. An ellipse is a figure bounded by a curve having no centre but two foci, from which it is generated. It owes its form to the section of a right cone oblique to its axis. In Plate VIII. is shown elliptical fig. described by a piece of string and pencil, which forms no part of a circle.

The words major and minor axes are terms used to describe the length and width of the ellipse or the diameters; they are also described sometimes as the transverse and conjugate axes.

PLATE V.

To strike a pattern for a Round Tapering or Flue Article (or a Frustum of a Cone).

Fig. 1 represents the diameter of both top and bottom, and Fig. 2 from G to F the upright height. Divide the circle with lines, as AB and CD, at right angles, then draw a line as *a b* in Fig. 3, and take upright depth required, as from F to G, mark off from *a* to *d*, and draw the lines *a c* and *d e* at right angles with *a b*, take the radius of the larger circle EB with the compasses, and mark off the distance from *a* to *c*, take also the radius of the small circle E to *q*, and mark it off from *d* to *e*, then draw a line from the points *c e* to cut the line *a d b*, with *b* as centre and radius *b e*, strike the curve *e h*, open the compass to *c*, still using *b* as centre, and strike the curve *c i o q f*. The circle Fig. 1 is divided into quarters; take one of them and divide it into any convenient number of equal parts as D to B, from *c* (Fig. 3) measure off a corresponding number of distances to *i*, the curve *c* to *i* shows one quarter of the pattern required, by adding on a like distance, as from *i* to *o*, represents half the

Plate. 5.

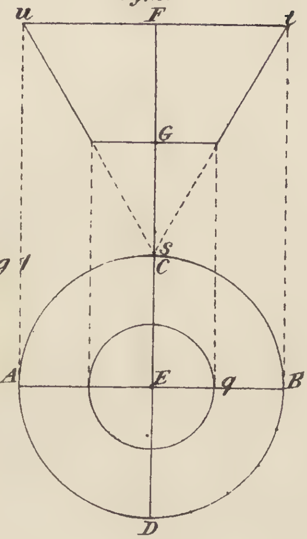


Fig. 2.

Fig 1

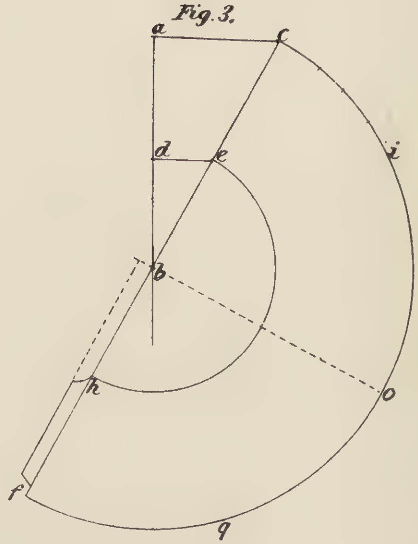


Fig. 3.

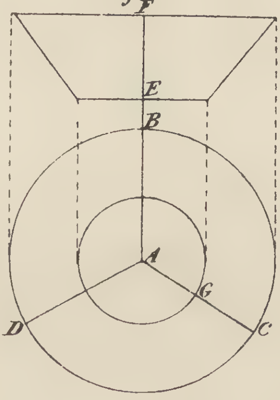


Fig. 5.

Fig. 4.

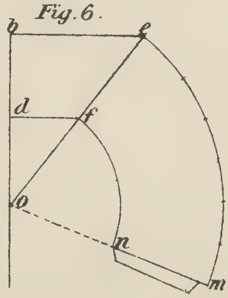


Fig. 6.

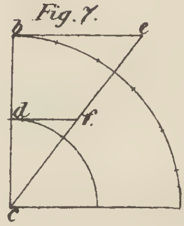


Fig. 7.

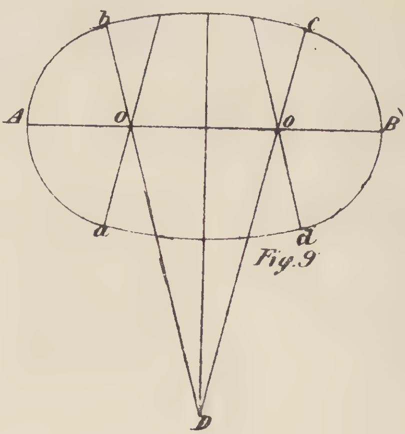


Fig. 9

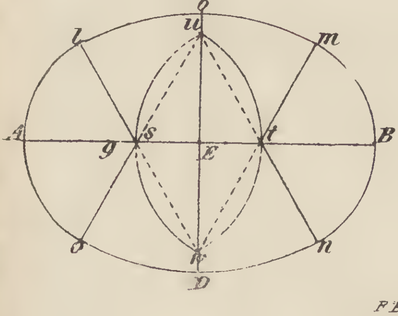


Fig. 8.

F. Bourquin Lith.

pattern, and the distance *c i o q f* the whole pattern required in one piece, draw a line from *f* to the centre *b*, and the required lap to be added on as shown.

To describe the plan of a Round Flue body to be cut in Three Pieces.

Fig. 4 represents the top and bottom of the body; this is to be divided into three parts, which is done in a very simple manner. The radius by which a circle is struck will measure six times the distance on the circumference, as shown in Plate III, Figs. 1 and 2, so that by drawing a line from every alternate point to the centre will divide the circle into three, as BCD. The pattern for this body is shown by Fig. 6, draw *o b e* at right angles; take the perpendicular height FE (Fig. 5), and mark it off from *b* to *d* (Fig. 6). Draw line *d f* at right angles with *b o*. Take the radius of the outer circle at AB, and mark it off from *b* to *e*, and the radius AG to be marked off from *d* to *f*. Draw a line from the points *e f* to cut the line *b o*. Take *o* as centre, radius *o f*, to strike the curve *f n*. Open the compass to *e*, still using *o* as centre, and strike the curve *e m* (Fig. 6). Divide the part of circle DB into any convenient number of equal parts, and measure

off a corresponding quantity of equal parts in Fig. 6 from *e* to *m*. Draw a line from *m* to the centre *o*, which gives the pattern of one third of the body required, the perpendicular height of which will be equal to EF.

Fig. 7 gives the flue or slanting height of the same articles; the only difference between this and Fig. 6 is, that the radius is taken from *d* and *b*, instead of *f* and *e*.

Fig. 8 represents an oval (this is recommended for general practical use).

Let AB be the given length, and *b*D the width.

From B set off *g* equal to *b*D the given width.

Divide *g* A into three equal parts. Set off two of these parts on each side of E, as *s* and *t*.

From *s* and *t*, as centres, with radius *s t*, describe curves or arcs, cutting each other in *u w*. From *u* and *w* draw lines through *s* and *t*, and produce them as *o n l m*. Take *s* as centre, *s*A as radius; draw the curve *o* A *l* and *t* as centre; draw the curve *m* B *n*. Then with *u* and *w* as centres, radius *w l*, strike the curves *l b m* and *o* D *n*, which will complete the oval required.

Fig. 9 shows a kind of oval very frequently used in the manufacture of various articles; a method of getting this shape is required so as

to cut a flue or tapering body (which will be shown in a future example).

Take AB the given length, set the compass to nearly half the required width. From A and B mark off the points *o o*, and strike semicircles *a* A *b* and *c* B *d*.

Take any distance on this curve, as from A to *b*, or further if required, and mark off a corresponding distance from B to *c* and *d*.

Produce lines from *b o* and *c o* until they meet as at D. Then with radius D *b* strike the remainder of the curves *b c* and *a d*, which will give the oval required.

Cone and Frustum of a Cone.

[1] A cone is a solid the base of which is a circle, but which tapers to a point from the base upwards. If a cone be cut horizontally, that is, parallel to the base, all such sections will be circles.

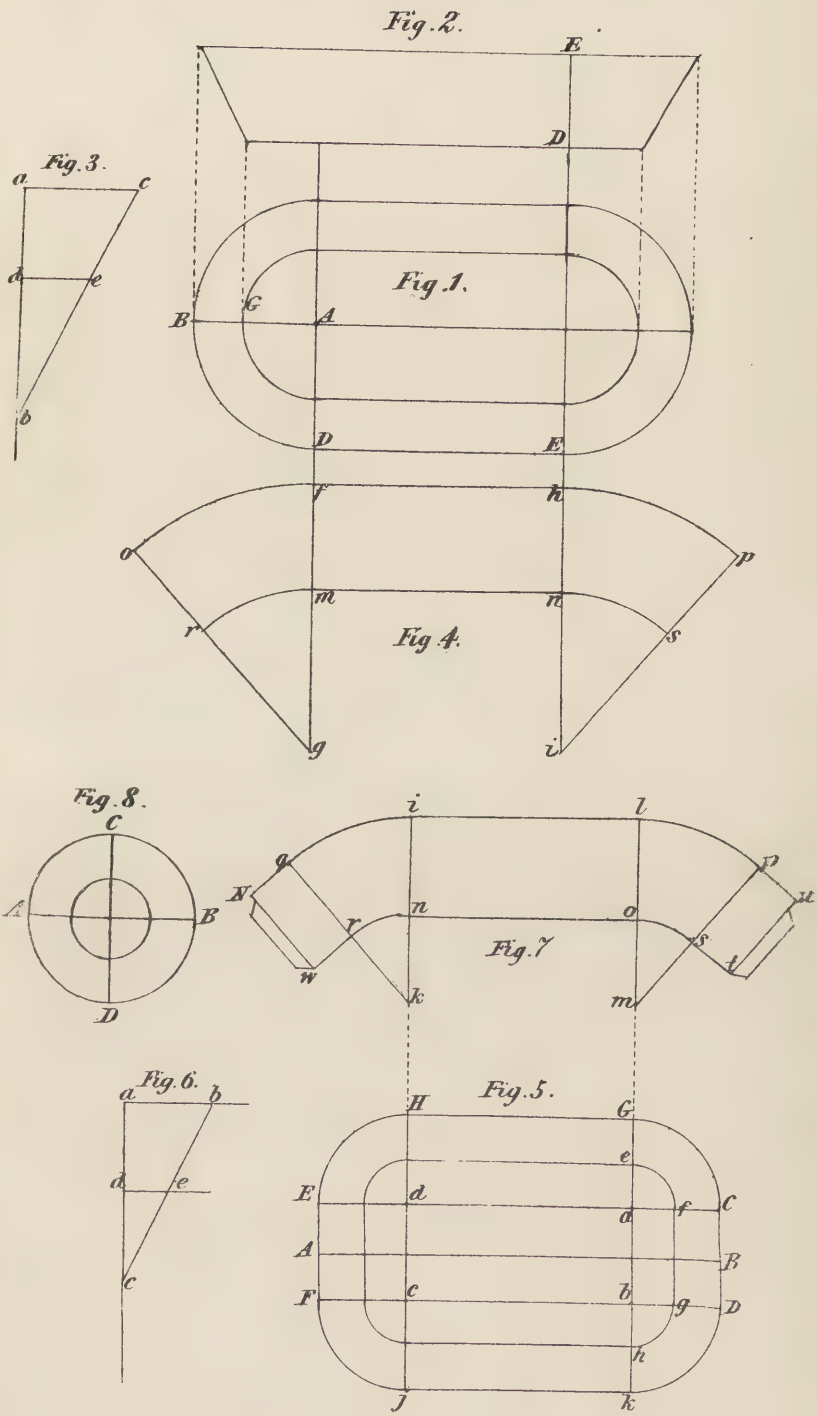
Fig. 2 (Plate V.)—Take *t* F *u* for the base, *u s* and *t s* form a cone: the point *s* being cut off by the line G, the Fig. from F to G only being required, is called a section or frustum of a cone, the point or apex being cut off.

PLATE VI.

To strike the pattern of an article where the Sides are Straight and the Ends Semicircular.

Fig. 1 shows the size and shape of the required article at top and bottom. Fig. 2 is the upright height. Having drawn figs. 1 and 2, showing the plan and elevation, proceed with fig. 3; draw *a b* and *a c* at right angles, take the depth ED (fig. 2), and mark it off from *a* to *d*, draw *d e* parallel to *a c*, take the radius AB, and mark off the distance on the line *a c*, and the radius AG, marking off the point from *d* to *e*, then draw a line from the points *c* and *e* to cut the line *a b*, which will give the slanting height and the radius. This pattern is to be made in halves joined at each end as at B. To strike the pattern shown in fig. 4, make the straight part for the side *f h* equal DE (fig. 1). Extend the lines *f m* and *h n* indefinitely, take the distance from *c* to *b* (fig. 3), and mark off the points from *f* to *g* and *h* to *i*, then with radius *b c* taking *g* and *i* as centres, strike the curves *f o* and *h p*, with radius *b e* (fig. 3), still using *g* and *i* as centres,

Plate. 6.



strike the curves *m r* and *n s*. Divide the curve from D to B (fig. 1) into any convenient number of parts with the compasses, and mark a similar number of parts on the curve *f o* (fig. 4); make *h p* equal *f o*, and draw lines from *p* to *i* and *o* to *g* the centres, which will give one half the pattern required.

To strike the pattern of an Oblong Tapering Pan in two parts or sections.

Fig. 5.—Draw lines EC and FD, the distance apart required for the straight part of the ends. Draw HJ and G *k*, the distance apart required for the straight part of the sides. Take the points *a b c d* for centres, and then draw curves, or the corners, as at GC and *e f*, &c., at each of the corners, then draw straight lines to meet the curves as at HG and CD, and *f g*, and so on, which will give the size of the article both top and bottom; the line AB shows where the two halves meet for jointing together in fig. 6. Draw *a b* and *a c* at right angles, take the required depth from *a* to *d*, draw *d e* parallel to *a b*, then take the radius from *a* to G, mark off the point from *a* to *b*, also the radius of the small curve from *a* to *e*, mark off from *d* to *e* (fig. 6), draw the line from *b* to *e*

to cut the line $a\,b$; from b to e will give the slanting depth.

Fig. 7 is the development of the pattern. Make the straight part from i to l equal GH, the depth from $i\,n$ and $l\,o$ to equal $b\,e$ (fig. 6), take the distance $b\,c$ (fig. 6), and mark off from i to k and l to m (fig. 7), take k and m as centres, with radius $c\,b$ strike the curves $i\,q$ and $l\,p$, divide the length of the curve from C to G, and dot off the same distance from l to p, make $i\,q$ equal $l\,p$, draw the lines $p\,m$ and $q\,k$; with radius $c\,e$, still using m and k as centres, strike the curves $o\,s$ and $n\,r$. Draw lines $p\,u$ and $s\,t$ at right angles with $p\,m$, making $p\,u$ equal to CB (fig. 5), draw $u\,t$ parallel to $p\,s$, finish the opposite end in like manner, adding the lap in both instances as required. Where wiring or edging is required, add on accordingly.

Fig. 8 shows two circles divided into four equal parts, ACBD, equal to the four corners of fig. 5, with a little calculation the pattern may be obtained without going through the process of again constructing fig. 5. To illustrate this, take an article, say 10 inches from A to B (fig. 5), and 7 inches from H to j, the corner EH to be the section of a 4 inch circle, as from A to C (fig. 8). The diameter AB being 4 inches, subtract 4 inches from 7 inches,

would leave 3 inches straight at end, as from F to E.

Again, subtracting the 4 inch circle from 10 inches the given length, will leave 6 inches straight in the sides, as from H to G, then drawing lines *n o* and *i l*, the required depth as previously described, draw the *l o* and *i n*, the perpendiculars 7 inches apart; then drawing the corners as previously described, adding on an inch and a half, as from *p* to *u* and *q* to N, at right angles with *p m* and *q k*, will give the required pattern.

PLATE VII.

To strike the pattern for a Tapering Oblong article in one piece, such as a flue oblong candlestick.

Fig. 1 is the size, top and bottom, and fig. 2 upright height. Take the perpendicular height *a b* (fig. 2), and mark it off from *b* to *d* (fig. 3). Take the radius for the corners *a* C (fig. 1), and mark it off from *b* to *c* (fig. 3), also the radius *a e*, mark off from *d* to *e*, drawing a line from *c e* to cut the line *b a*, which gives the slanting height and the radii required for

striking the corners. Draw the lines *e f* and *a c* (fig. 4) the same distance apart as *e* to *c* in fig. 3. Draw the perpendiculars *a e* and *c f* (fig. 4) equally distant as AC, making the straight part of the side required. With radius *a c* (fig. 3), using *b* and *d* (fig. 4) as centres, strike the curves *a p* and *c g*, and with radius *a e* (fig. 3), still using the same centres in fig. 4, strike the curves *e q* and *f h*. Take the length of the curve DH (fig. 1), and dot off the same distance from *c* to *g* (fig. 4), make *a p* equal to *c g*, draw lines from *p* and *g* to the centres *b* and *d*, draw *p r* and *q s* at right angles with *p b*. Take the distance from E to G (fig. 1), and make the same distance from *p* to *r* and *q* to *s* (fig. 4). Draw *r z* parallel with *p b*, from *r* mark off point *z*, the same length as *p* to *b*, then using *z* as centre strike the curves *r t* and *s u*, making the curve *r t* equal *p a*, draw line from *t* to centre *z*, draw *t w* and *u x* at right angles to *t z*; taking the distance from B to *k* (fig. 1), mark off the same distance from *t* to *w* and *u* to *x*, draw *w x* parallel with *t u*, and proceed in the same manner with the other end; adding on the lap, as shown, will make the pattern complete in one piece, being joined together at *k i*.

Plate 7

Fig. 2

Fig. 1.

Fig 4

Fig. 3.

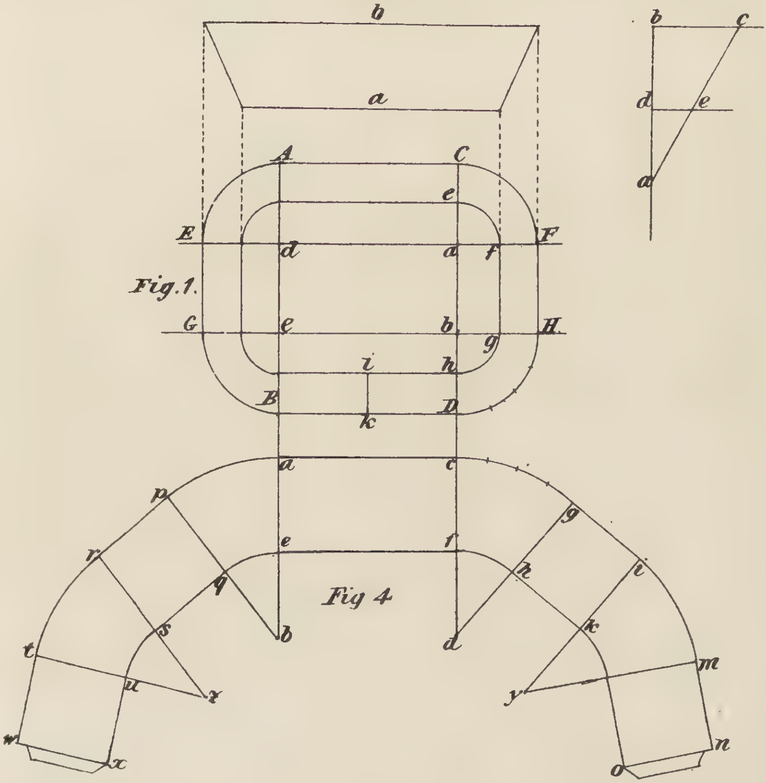


Fig. 6.

Fig. 5.

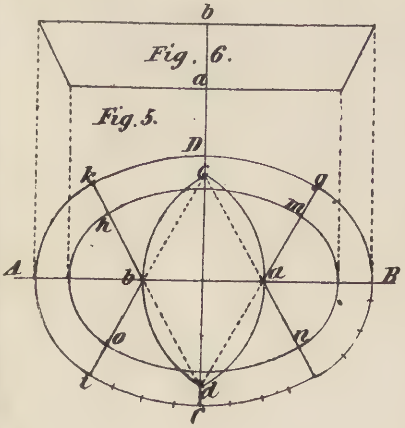
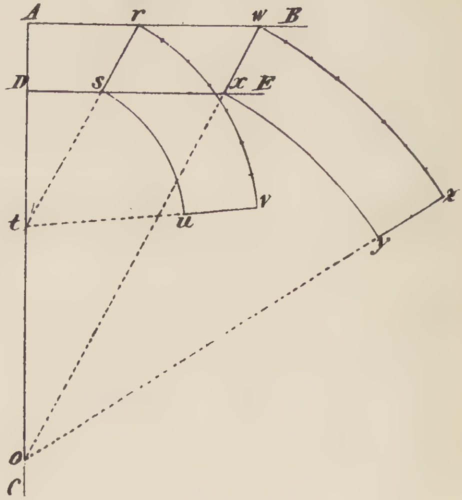


Fig. 7



To strike the pattern for a Tapering Oval article in Four pieces or sections.

Fig. 5.—Draw the smaller oval (as explained in fig. 8, Plate V.) first the size required for the bottom, then from the same centre, which in this instance is *a b c d*, describe the outer oval as much larger as required for the top of the article, drawing the diameters AB and CD at right angles.

Fig. 6 shows the perpendicular height. Draw AB and DE (fig. 7) parallel, the same distance apart as *a b* (fig. 6), being the upright depth, make AC at right angles with AB and DE, take the radius which the end section of the oval is struck by, and mark it off on fig. 7, *i.e.*, take the distance *a* B or *a g* (fig. 5), and set it off from A to *r* (fig. 7), and the radius *a m* or *a n*, and mark off the same distance from D to *s*. Draw a line from *r s* to cut the perpendicular AC at *t*, then with *t* for centre and *t s* as radius, strike the curve *s u*; open the compasses from *t* to *r* as radius, and draw the curve *r v*. Take the length of the curve from *k* to *i* (fig. 5), marking off a convenient number of parts, then taking a like distance with a corresponding number of parts, as from *r* to *v* (fig. 7); now draw the line from *v* to

the centre *t*, which will give the pattern of the end section.

For the pattern of the side take the radius *d k* or *d g* (fig. 5), mark off an equal distance from A *w* (fig. 7), and the radius *d h* (fig. 5), mark off from D *x* (fig. 7); draw a line from points *w x* to cut the perpendicular at *o*; with *o* as centre, radius *o x*, strike the curve *x y*, open the compass from *o* to *w*, strike the curve *w z*, take the length of the curve *k g* (fig. 5), and take a corresponding length of curve from *w* to *z* (fig. 7), then draw a line from *z* to centre *o*, which by adding the usual laps will complete the side.

PLATE VIII.

To describe a Tapering Oval body in one piece.

Draw the two ovals (fig. 1) as previously explained, and proceed with fig. 3 (as in Plate VII. fig. 7). Draw AB and AC at right angles, and the required depth from A to D; draw D E parallel to AB; from centre *a* (fig. 1) take the radius *a m*, that the curve BC is struck by,

Plate 8.

Fig. 3.

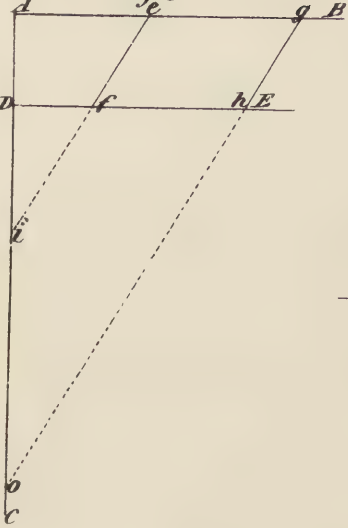


Fig. 2.

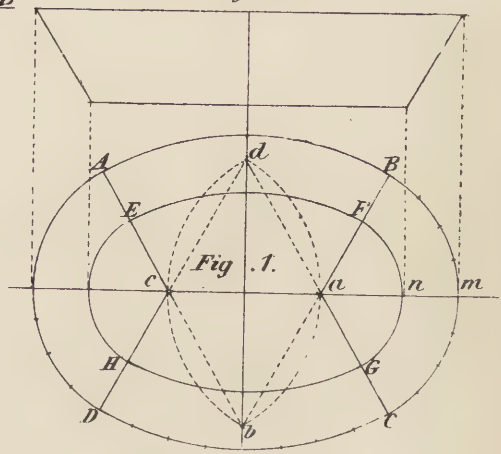
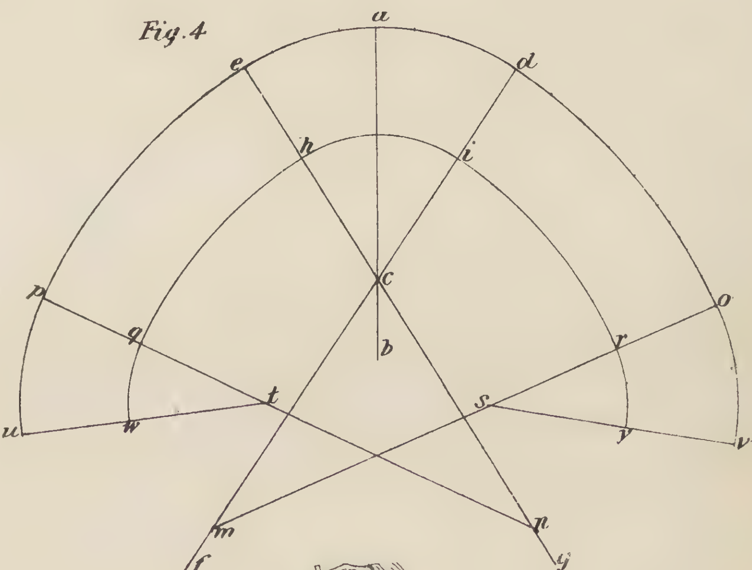
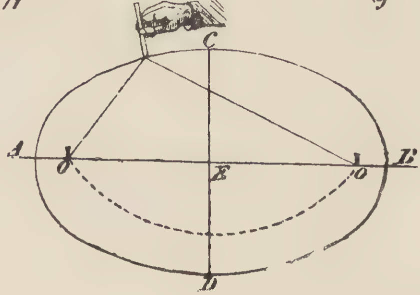


Fig. 4





and mark off the distance on fig. 3 from A to *e*, also the radius of the smaller curve as *a n*; mark off from D to *f* (fig. 3); draw *e f* to cut the perpendicular line AC at *i*. Take the radius of the curve of the side from *b* to A or *b* to B, mark off the distance from A to *g* (fig. 3), then take the radius from *b* to E (fig. 1), being the radius by which the curve EF is struck, and mark it off on the line DE to *h* (fig. 3), draw a line from the points *g h*, to cut the perpendicular line AC at *o*, and this will give the radii for describing the pattern, the development of which will be found in fig. 4.

To commence fig. 4, draw the line *a b*, set the compasses from *i* to *e* (fig. 3), and on the line *a b* (fig. 4), taking *c* for centre, strike the curve *e a d*, make the length of the curve *e a d* the same as B *m* C (fig. 1). Draw lines from *d* and *e* through the centre *c*, and extend them indefinitely as *f* and *g*. Take the distance *i f* (fig. 3) for radius, still using *c* (fig. 4) as centre, strike the curve *h i*. Now take the distance *o* to *g* (fig. 3), with the compasses, and from *e* (fig. 4) mark off the point *n* on the line *e g*, likewise mark off a like distance *d* to *m* on the line *d f*, using *n* and *m* as centres, strike the curves *d o* and *e p*, with radius equal to *o h* (fig. 3), still using *m* and *n* as centres, strike the curves *i r*, and *h q*.

Divide off the length of the curve C to D (fig. 1), and take the same distance from *d* to *o* (fig. 4), draw line from *o* to the centre *m*, make the distance from *e* to *p* the same as from *d* to *o*, draw line from *p* to centre *n*, mark off the points *t* and *s*, on the lines *p n* and *o m*, equal to the distance from *a* to *c*, using *t* and *s* as centres, radius *t p*, strike the curves *p u* and *o v*, then with radius *t q* strike the curves *q w* and *r y*, take the length of the curve from *a* to *d*, mark off like distances from *o* to *v*, and *p* to *u*, draw lines from *u* to centre *t* and from *v* to *s*, which will complete the pattern.

A method of drawing an Ellipse or Oval with a string and pencil.

Make the given diameters AB and CD at right angles to each other at their centre E. Take the distance from E to A, then using C as centre, draw an arc to cut the diameter AB in *o o* (these two points *o o*, are called the *foci* of the ellipse). Place a pin at each point where the curve cuts the line AB, as at *o o*, and another at C, pass a string round the three pins, and tie it securely, thus forming a triangle with the string, as *o o* C. Take out the pin at C and substitute the point of a pencil, which may be drawn along, moving with the

string, and the point will thus trace a perfect ellipse.

PLATE IX.

To describe the pattern of an Egg-shaped Oval Tapering body.

FIG. 1. Draw AB and CD at right angles, and from E, with radius EH, draw a circle cutting the line CD at F; from G and H draw lines through F, and produce them indefinitely, and GH and F will be the centres to strike the remainder of the figure (as shown in Plate IV. fig. 3), then from the same centres draw the larger oval as much larger as the flue requires.

FIG. 2. Draw AB and ED the required depth, and BC at right angles, mark off B *a* and D *e* equal to EC and EJ (fig. 1). Draw line from *a e* to cut the perpendicular line at *h*. Take HA, and mark off from B to C on the line BA. Take HG and mark off from D to *d* on the line DE, and draw C *d* to *g*. Take the radii FM and FK and mark off from B to *e* and D to *f*, and draw *e f* to *i*.

FIG. 3. Draw line *l o* with radii *h a* and *h e*

(fig. 2); using *o* (fig. 3) as centre, strike the curves *k l m* and *r p*. Take the length of curve from A to C (fig. 1), and dot off a like distance from *l* to *m* and *l* to *k* (fig. 3). Draw lines from *m* and *k* through the centre *o*, and produce them indefinitely, take radius *g* to C (fig. 2), and from *k* mark off *q*, and from *m* mark off *r*, take *q* and *r* as centres, radius *r m*, and draw curves *m s* and *k t*; make *m s* and *k t* the same length as AN and BM, draw lines from *t* to centre *q*; and from *s* to *r*, with radius *g d*, draw curves *p u* and *r v*. Take the radius *i e*, and from *t* and *s* mark off *m* and *x* for centres, and strike the curves *t y* and *s z*: make *s z* same length as ND, and draw lines from *z* to the centre *x*; and from *y* to *m*, with radius *i f*, describe the curves from *u* and *v*, which will complete the pattern.

These figures heretofore described are recommended to be well studied before reading the ensuing ones.

Another method of describing an Oval Tapering body.

Fig. 4 shows the oval the size required for the bottom. Draw the diameters AB and CD at right angles, and describe the oval as already explained.

Plate. 9.

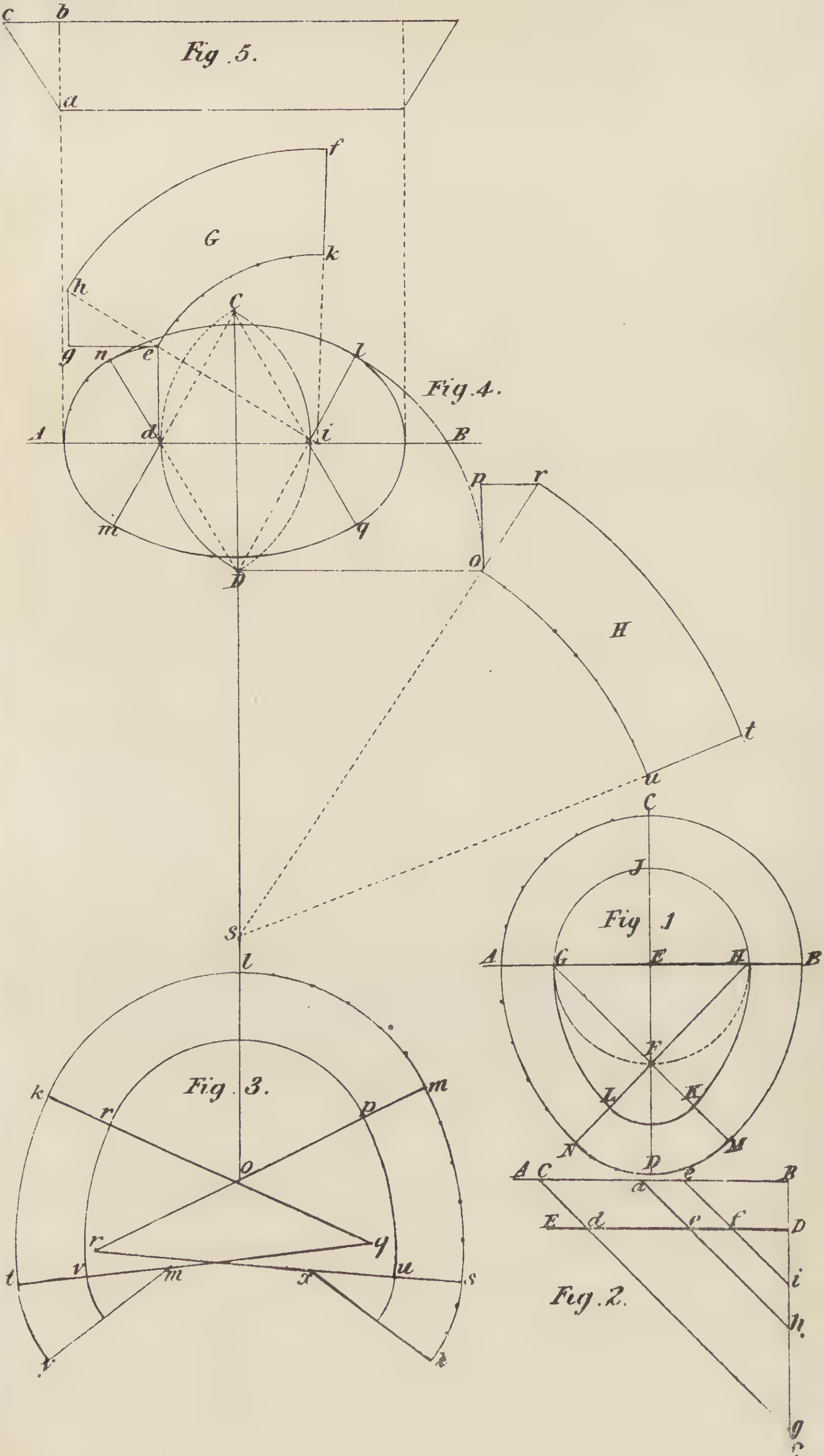


Fig. 5.
c b a f k h g n e G
Fig. 4.
C A d i B l m q D p r o H t u
S
Fig. 1
C J A G E H B F L K N M D
Fig. 2.
A C a e B E d c f D i h g
Fig. 3.
l k r m p o r q t v m x u s

Fig. 5 shows the upright height and flue required. To strike the pattern G, which is the end section, *d* being the centre from which the curve *m n* is struck, draw a line *d e* at right angles with AB. Produce or extend the curve *m n* to cut the line *d e* at *e*, draw the line *e g* at right angles with *d e*, make *e g* the upright height as *a b* in fig. 5. Draw *g h* at right angles with *g e*; *c b* in fig. 5 showing the flue required, mark off a like distance from *g* to *h*. Draw line from points *h e* to cut the line AB at *i*, taking *i* for centre on the line A B, with the radius *i h* draw the curve *h f*, and with radius *i e* draw the curve *e k*. Measure off the length of curve *m n* from *e* to *k*, and draw line from *i k* to *f*.

Proceed with the side section H in the same manner. Extend the line CD indefinitely, D being the centre by which the curve *n l* is struck, draw a line D *o* at right angles with C D; extend the curve *n l* as dotted, until it cuts the line D*o*; draw line *op* at right angles with D*o*, make *op* the upright height as from *a* to *b* (fig. 5). Draw *p r* at right angles with *p o*, make *p r* the required flue as *b c* (fig. 5), draw line from *r o* to cut the extended line C D at *s*; with *s* for centre, and radius *s r* draw the curve *r t*, and with radius *s o* strike the curve *o u*. Measure the length from *m* to *q*,

taking a like distance from *o* to *u*; now draw line from *s u* to *t*, which completes the pattern. This pattern will, after being well studied, be found an excellent introduction to Plate X; it is a different method from that described at Plate VII. figs. 5 to 7, and in other diagrams, but the result will on practice be found precisely the same. In these and the foregoing figures, the tapering must be equal on all sides.

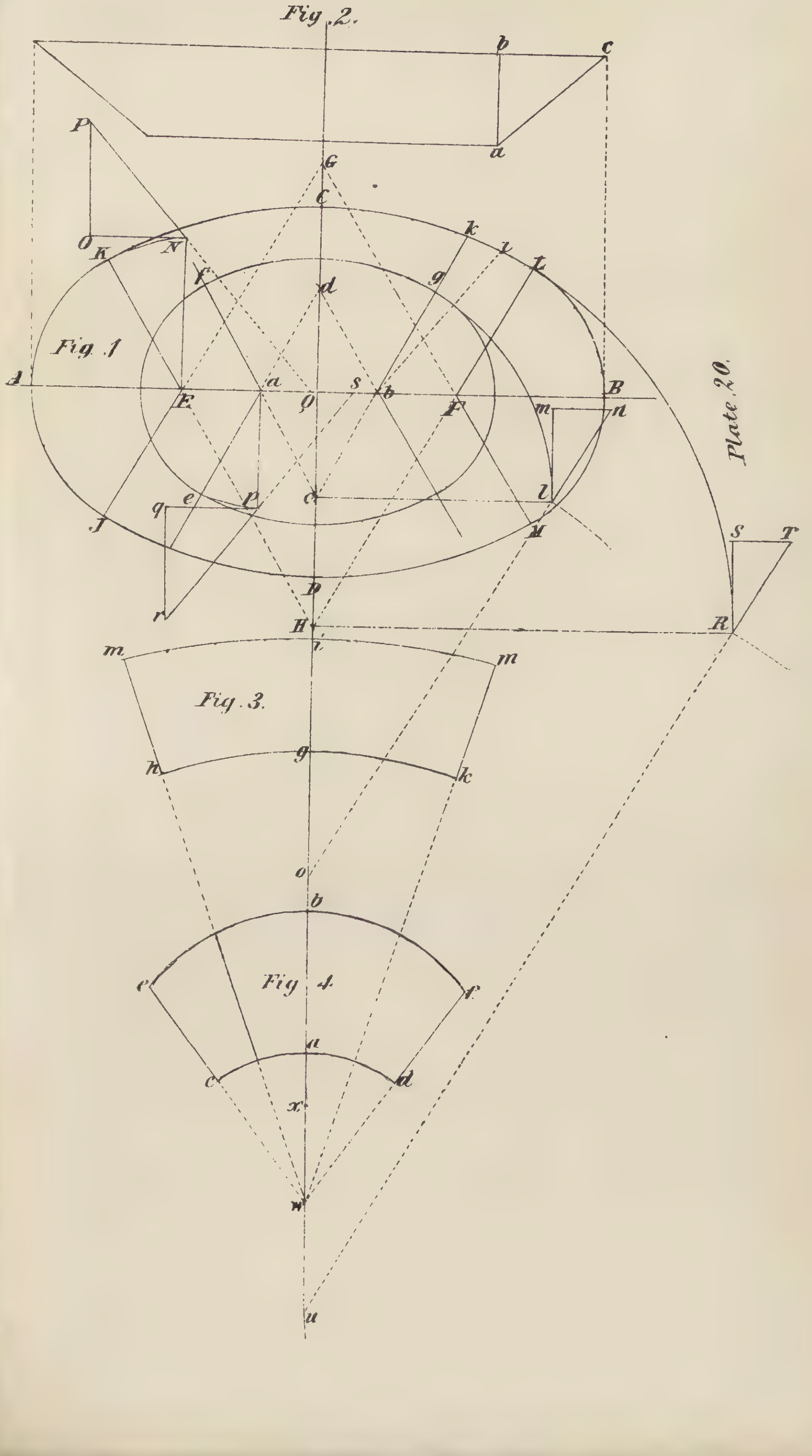
PLATE X.

To describe a Tapering Oval body, where the tapering is not equal on all sides.

(In this case more tapering at the ends than at the sides.)

Fig. 1 shows the diameters of two distinct ovals, each one being described by a separate set of centres. To proceed with the larger or outer oval, which (as well as the smaller or inner one) is constructed in the same manner as described in fig. 8, Plate V., take the required diameters, as AB and CD, the centres being EF and GH. The smaller oval will have to be constructed in the centre of the

Plate 10.



larger one, according to the given length and width required for the bottom of the article, the centres by which this oval is struck being *a b* and *c d*: fig. 2, from *a* to *b*, shows the upright height.

Fig. 3 shows a pattern of the side, which is obtained in the following manner: H being the centre by which the curve KL (fig. 1) is struck, draw line HR at right angles with the perpendicular line GH, and extend the curve KL as dotted, to meet the line HR. Draw the line RS perpendicular with the line HR, mark off the depth from R to S, equal to the upright height, as *a b* (fig. 2). Draw ST at right angles with RS, take the distance at D between the two ovals on the line CD (the width between them being the flue of the sides), mark off the same distance from S to T, draw a line from the points TR, and extend it, as shown by the dotted line, to cut the extended perpendicular line CD at *u*; with radius *u* R, taking for the centre any part of the perpendicular line (there not being space enough on the plate to show the centre), and strike the curve *m i m*: *c* being the centre by which the curve *f g* (the side of the smaller oval) is struck, draw line *c l* at right angles with the perpendicular line CD, extending the curve *f g* with the same radius to meet the line *c l*.

Draw line $l m$ at right angles with $c l$, again taking the distance $a b$ (fig. 2) from l to m (fig. 1). Draw a line $m n$ at right angles with $l m$. Take the distance again between the two ovals at the side C, and mark off the distance on the line $m n$, draw a line from the points n and l to cut the perpendicular line CD as at o. Take the distance from l to n, or from R to T, and measure off a like distance from i to g (fig. 3), being the slanting height of the body at the centre of the side. Take the distance from o to l, and from g mark off the point w; with w as centre, radius $o l$, strike the curve $h g k$. Extend the line $c b g$ (fig. 1), which shows the division of the smaller oval, to k on the curve of the larger one, the point L being the right sectional line of the larger oval, while the extended line $c b$ to k, would be the sectional line of the inner one; let the distance be equally divided as at i, draw line from i to b, being the centre by which the end of the smaller oval is struck, take the length of the curve from i to C, measuring off a like distance from i to m on each side of the perpendicular line, and draw lines from m to the point w, being the centre by which the bottom curve $g h k$ is struck; this being done, will complete the pattern for the side.

Fig. 4 shows a pattern of the end, which is

obtained as follows: E (fig. 1) being the centre by which the end of the large oval JAK is struck, draw line from E to N at right angles with the diameter AB, extend the curve JAK, to cut the line EN at N. Draw line from N to O at right angles with NE, make NO equal to *a b* (fig. 2) the upright height. Draw OP at right angles with ON, take the distance between the two ovals at the end on the line AB, being the flue of the end, and mark off a corresponding distance from O to P. Draw line from PN to cut the diameter AB at Q. With radius QN, and *x* (fig. 4) as centre, describe the curve *e b f*. Take *a* (being the centre by which the end of the smaller oval, as *f e*, is struck) and draw *a p* at right angles with the centre AB, extending the curve *f e* to cut the line *a p* at *p*, draw *p q* at right angles with *a p*, again taking the upright height as at *a b* (fig. 2), and mark off a like distance from *p* to *q*. Draw *q r* at right angles with *q p*, take the distance from A to the end of the smaller oval, and mark off the same from *q* to *r*. Draw a line from the points *r p* to cut the centre line at *s*, take the distance from *r* to *p*, or from P to N, which will give the slanting depth of the centre of the end, mark off the distance from *b* to *a* (fig. 4), take radius from *s* to *p* (fig. 1) and from *a* (fig. 4) mark off the point

w. With *w* as centre, radius *s p*, strike the curve *c a d*, take the length of the curve from B to *i* (fig. 1) and mark off a corresponding distance on fig. 4 from *b* to *f*, and *b* to *e*, draw lines from *f* and *e* to the centre *w*, being the centre by which the curve of the bottom is struck, which will complete the pattern for the end.

PLATE XI.

To strike the pattern for a Square Tapering article (or Pyramid).

Fig. 1 represents the size or projection, and fig. 2 the upright height or elevation. Draw the diagonals, and take distance from the centre *a* to *b* (fig. 1), and mark off the same in fig. 2 from *g* to *d*. Also take the distance (in fig. 1) from *a* to *l* or *k*, and mark off in fig. 2 from *h* to *e*. Draw a line from points *d e* to cut the perpendicular line at *f*. Then draw (in fig. 3) the perpendicular line *d f*, and take the radius *f d* (in fig. 2), and in fig. 3 describe the circle *h d k*, and with radius *f e* in fig. 2, still using *f* as centre in fig. 3, draw the smaller circle *e*, take the length of one side from *c* to *b*

Plate II.

Fig. 1.

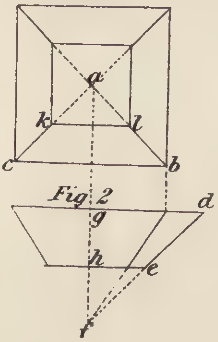


Fig. 3.

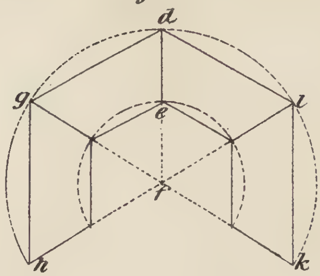


Fig. 4.

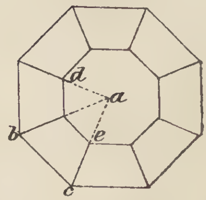


Fig. 5.

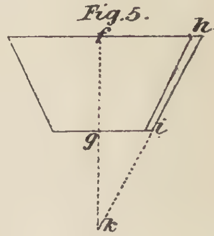


Fig. 7.

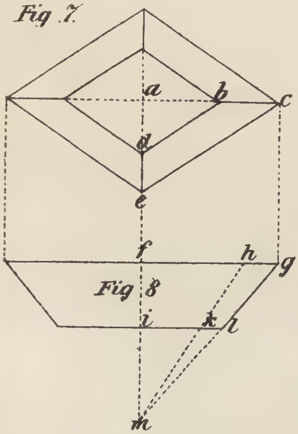


Fig. 9.

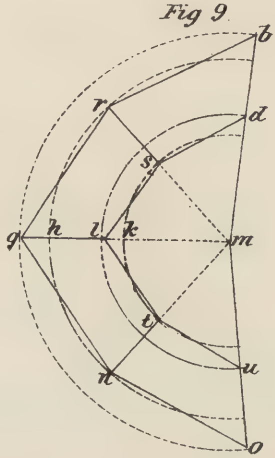


Fig. 6.

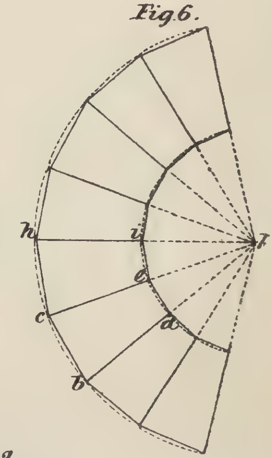


Fig. 10

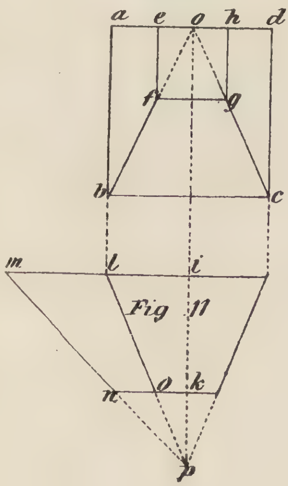
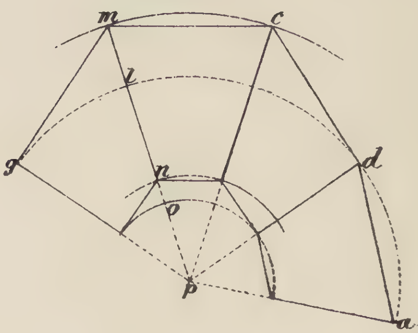


Fig. 12.



(fig. 1), and mark off the same four times on the larger circle (fig. 3), as *h g d i k*. Draw lines from these points to the centre *f*; join these points by lines, as *h g*, *g d*, &c., and from the points on the smaller circle in the same manner, which will complete the pattern.

To strike the pattern for a Tapering Octagon body, in one piece.

Fig. 4 represents the size of top and bottom (the method of striking this figure is given in Plate III. fig. 3 and 4), fig. 5 from *g* to *f*, being the upright height required, take the distance from the centre *a* to one of the extreme points as *c* (fig. 4), and from *f* mark off the same distance at *h* (fig. 5), and the distance *a* to *e*, mark off from *g* to *i*, draw the line *h i* to cut the perpendicular line *f g* at *k*. With radius *k h* (fig. 5) draw portion of circle as *h c b* (fig. 6), and with radius, *k i*, still using *k* as centre strike the curve *i e d* (fig. 6). Take the distance *b c* (fig. 4), and mark off eight times the same distance on the larger curve (fig. 6), as *b c h*, &c. Draw lines from all these points to the centre *k*. Draw straight lines from these points as from *h* to *c*, and *c* to *b*, and likewise from the intersecting points of the smaller curve, which will complete the pattern.

To strike the pattern for a Diamond-shaped Tapering body, in one piece.

Fig. 7 shows the size and shape required. Fig. 8 from *i* to *f*, the upright height. Carry the length of *a c* and *a e* (fig. 7), on fig. 8, from *f* to *g* and from *f* to *h*, also the distance from *a* to *b* and *a* to *d*, from *i* to *l* and *i* to *k*, and draw through *g* and *l* a line to cut the perpendicular at *m*, also through *h* and *k*. draw a line which will cut the perpendicular at the same point *m*. With the length of *m g*, *m h*, *m l*, and *m k* (fig. 8) as radii, describe the curves *g*, *h*, *l*, *k*, in fig. 9, from the centre *m*, and draw the line *g m*, carry the length *e c* (fig. 7), from *g* to *r* and *n* (fig. 9), also from *n* to *o* and from *r* to *b*, and draw lines from *r* and *b* to the centre *m*, likewise from *n* and *o*. Connecting these points by straight lines *b r*, *r g*, *d s*, *s l*, &c., will complete the pattern.

To describe the pattern of a Square Funnel, where one side is straight or upright.

Fig. 10, *a b c d* shows the projection for the top, *e f g h* the hole or bottom of the funnel. Fig. 11, from *i* to *k*, shows the elevation (or upright height). Draw lines from the points *b f* and *c g* to cut each other on the centre line

as at *o*. Carry the distance *o b* and *o a* (fig. 10) to fig. 11 from *i* to *m* and *i* to *l*, also the length *o f* and *o e*, from *k* to *n* and *k* to *o*. Draw the line *m n* to cut the perpendicular line at *p*. Also the line through the points *l* and *o*, which will cut the perpendicular line at the same point *p*, if the distances are taken correctly. Take the distance from *p m*, *p l*, *p n*, and *p o* in fig. 11 as radii, and describe the curves *m l n o* from the centre *p* (fig. 12). Take the length from *b* to *c* (fig. 10), and mark off the same from *m* to *c* (fig. 12), and draw the lines from *m* and *c* to the centre *p*, also take the distance *b* to *a*, and mark off the same from *m* to *g* and from *c* to *d*, and the distance *a* to *d* (fig. 10) mark off from *d* to *a* (fig. 12). Draw lines from these points to the centre *p*, and connect these points with straight lines, as *a d* and *d e*, &c., and also from the corresponding points on the smaller curves *n* and *o*, will complete the pattern required.

NOTE.—This will be found a very useful method for striking a square or rectangular tapering top or sides. Whether the tapering be proportionate or not, by drawing lines as *b f* and *c g* from the angles (which show the position of the top and bottom of the article required) to cut the centre line wherever the point *o* may come, by taking it as a working centre, one-half or a section of the pattern may be developed.

PLATE XII.

To describe the pattern for a Square or Rectangular Tapering Top or Tray, with sides and bottom, in one piece.

Fig. 1 shows the upright height and one half of the plan. Draw in fig. 2 the horizontal line *b d* and the perpendicular line *o p*. Draw the rectangle *e f g h* the same size as *e f g h* in fig. 1.

Take the length *a b* (fig. 1), and mark off corresponding distances from *e* to *b*, *h* to *d*, and *o* to *p* (fig. 2), and draw through the points *b p* and *d* the lines (at right angles) *b q*, *s t*, and *d r*; and carry the length *i l* to *b q* and to *d r*; also the length of *u l* from *p s* and *t*. Then draw the lines *q f*, *s f*, *t g*, and *r g*, which will complete one half of the pattern.

To describe the pattern for a Hexagon Mould or Tray, having the bottom and sides in one piece.

Fig. 3 shows the elevation and half an hexagon for the plan. To obtain a development of the pattern, draw (in fig. 4) the perpendicular *b c*, and draw the half hexagon *e f g h i*, the same size as *e f g h i* (fig. 3).

Plate 12

Fig 1

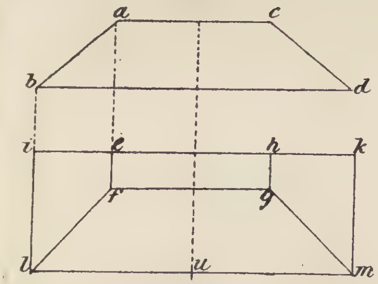


Fig 2

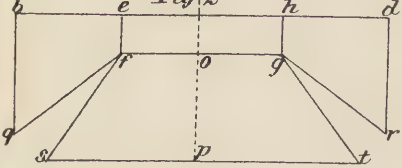


Fig 3.

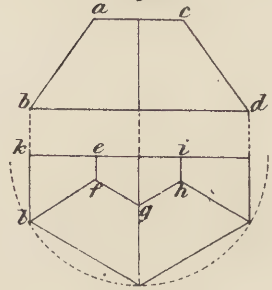


Fig 4

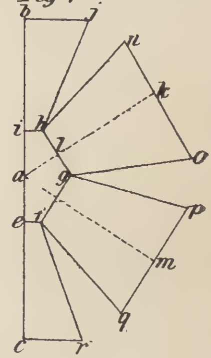


Fig 6

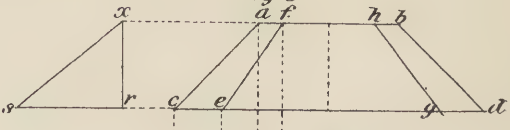


Fig 5.

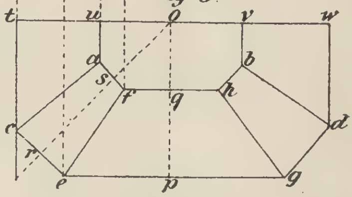


Fig. 8.

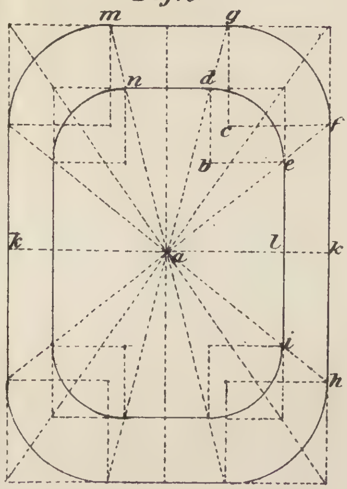


Fig 7.

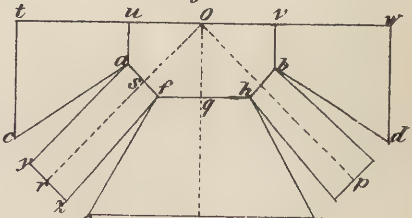


Fig.10.

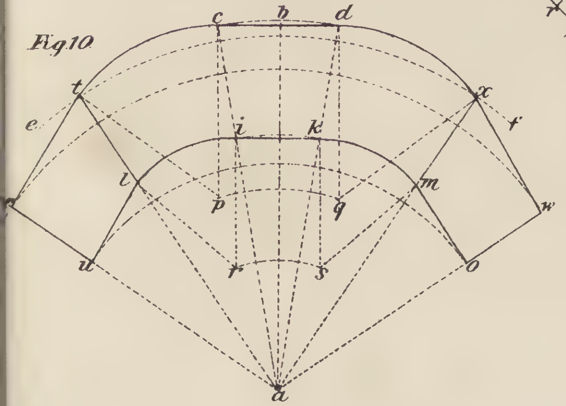
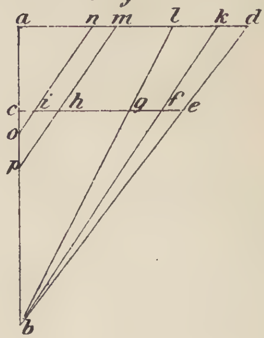


Fig 9



Divide the lines *h g* and *g f* into equal parts, and draw the lines *a k* and *a m*; then carry the length of *a b* (fig. 3) from *l* to *k* (fig. 4). Draw through *k* the line *n o* parallel with *h g*. Take the length *k l* (fig. 3), and mark off the same from *k* to *n* and *o*, and draw the lines *h n g o*: *h g n o* is the sixth part of the pattern. Proceed in the same manner to draw the remainder, one half of the pattern (as well as the plan) only being shown here.

To describe the pattern of an Irregular Octagon Pan or Tray, with the sides or bottom in one piece.

Figs. 5 and 6 show the required projection and elevation, having drawn which, proceed with the development of the pattern in fig. 7. Draw the half octagon *u a f h b* and *v* to the same dimensions as the corresponding letters in fig. 5. Draw the horizontal line *t w* and the perpendicular line *o c*. Divide the sides *a f* and *h b* into equal parts, and draw the lines *o r* and *o p*, then carry the length of the line *a c* (fig. 6)—being the slanting height of the larger sides—from *q* to *c*, from *u* to *t*, and from *v* to *w* (fig. 7). Draw from *t* and *w* lines perpendicular, and through the point *c* draw the line *e g* parallel with *t w*.

Take the distance from *t* to *c* (fig. 5), mark off the same in fig. 7 from *t* to *c*, *w* to *d*, *c* to *e*, and *c* to *g*, and draw the lines *c a*, *e f*, *g h*, and *d b*.

Then in fig. 6 draw the perpendicular line *x r*, and from fig. 5 take the projection of the small side the distance *s r*, and carry the same from *r* to *s* (fig. 6), and draw line *s x*, the length of which should now be transferred from *s* to *r* (fig. 7). Draw *y z* parallel to *a f*.

Take the distance *r e* (fig. 5), and mark off the same from *r* to *y* and *z* in fig. 7, draw lines *y a* and *z f*. For the other side *p* proceed in like manner, which on being done will complete half the pattern.

To strike the pattern of an Oblong Pan, with Round Corners, but struck from different centres, and tapering more at the ends than the sides.

To construct the plan fig. 8, first draw the larger rectangle and the diameter lines, also the diagonals, and from the diagonals draw the four lines showing the width and length for the bottom. Draw the quadrants (or quarter circles) for the corners, as *g f*, from the centre *c* any size required, and from the points *g* and *f* draw lines to the centre *a*, which will give

a proportionate size for the corner of the bottom, as shown in the curve *d e*, struck from *b* as centre.

Having drawn the plan, proceed now with fig. 9. To obtain the radii required draw *a b* and *a d* at right angles, from *a* to *c*, take the upright depth required, and draw *c e* parallel with *a d*, then carry the lengths of *a g*, *a f*, and *a k* (fig. 8), to *a d*, *a k*, and *a l* (fig. 9), also the distances *a d*, *a e*, and *a l* (fig. 8), to *c e*, *c f*, and *c g* (fig. 9), and draw lines from the points *de*, *kf*, and *l g*, to cut the perpendicular *a b* at *b* (all cutting at one point), then take the lengths from *c* to *g* and *b* to *d* (being the radii of the corners), and carry them from *a* to *m*, and *a* to *n*, and draw the lines *m p* and *n o* parallel with *k f*.

To proceed with the pattern drawn in fig. 10, the perpendicular line *a b*, take the lengths of *b d*, *b k*, and *b l* in fig. 9 as radii, and describe from point *a* as centre the curves *c d*, *e f*, and *g w* (fig. 10), also take the radii *b e* and *b g*, and from the same centre *a* (fig. 10) strike the curves *i k* and *u o*. Then carry the length *m g* (fig. 8) on the curve *c d* (fig. 10), and draw the lines *c a*, *d a*, and *c d*. From the points *c*, *d*, *i*, and *k*, draw perpendicular lines as *c p*, *d q*, *i r*, and *k s*. Take the length *p m* (fig. 9) and carry the same from *c* to *p* and *d* to *q*

(fig. 10); take also the length $o\,n$, and mark off the same from i to r and k to s. From p and q as centres, radius $p\,m$, strike the curves $c\,t$ and $d\,x$ to meet the curve $e\,f$, draw the lines $t\,p$ and $x\,q$, also the lines $t\,a$ and $x\,a$; then from r and s as centres, radius $o\,n$, describe the curves $i\,l$ and $k\,m$. Now take the distance from f to k (fig. 8), and mark off the same distance from t to v on the curve g, also the same distance from x to w, and draw lines from v to a and from w to a. Draw the lines from t to v and from x to w, also $l\,u$ and $m\,o$, which develops one half of the pattern.

PLATE XIII.

To describe a Pattern for a Tapering Top, the base being straight at the sides, and with circular ends, the hole in the top to be circular, and parallel with the base.

(*Similar to a Tea Bottle Top*).

Fig. 1 shows the plan and elevation required. Draw the lines $a\,d$ and $c\,b$, the required width of the top, and draw $a\,c$ and $d\,b$ at right angles with them, and through the centres by

Plate 13.

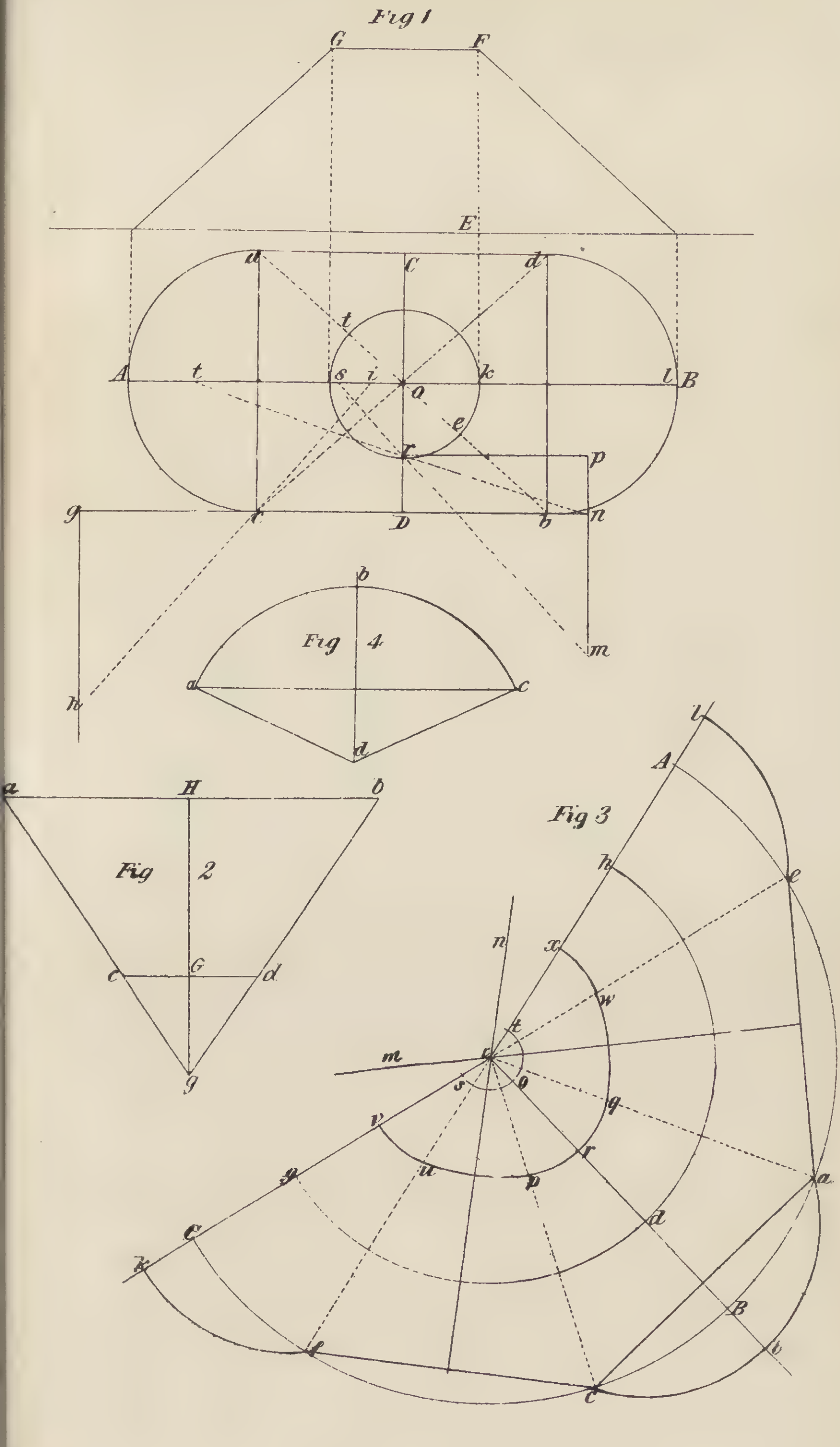


Fig 1
G
F
E
d
C
d
t
A
t
s
i
o
k
l
B
e
r
p
g
r
D
b
n
m
h
b
Fig 4
a
c
d
a
H
b
Fig 2
c
G
d
g
Fig 3
l
A
h
e
n
x
w
t
m
s
o
q
v
r
a
g
u
p
d
c
k
B
b
f
c

which the circular ends are struck. Then draw the diagonal lines *a b* and *c d*, which will give the centre *o*, and draw the diameters AB and CD at right angles through the centre *o*. Take the distance from E to F, being the upright height, and mark off a like distance on the line H to G (fig. 2), draw the lines *a b* and *c d* at right angles with the line HG. Take the length of the diagonal line *a b* (fig. 1), and make it equal to *a* H *b* (fig. 2), take the distances from the centre *o* to *t*, and *o* to *e* (being the diameter of the circle), and mark off corresponding distances on fig. 2 from G to *c* and G to *d*. Draw lines from points *b d* and *a c* to cut each other at *g*, with radius *g a* or *g b*, with *i* (fig. 3) as centre, strike the curve ABC (which will give a boundary line to describe the pattern on).

The curve of the end (fig. 1) being a semicircle, extend the line *b c* to *g*, which will be at right angles with *a c*, take the distance EF (being the upright height) and mark off a like distance from *c* to *g*, draw *g h* at right angles with *c g*, take the distance from *k* to *l*, being the taper of the end, and mark off a like distance from *g* to the point *h*, draw line from *h c* to cut the line AB at *i*; with radius *i c*, taking *d* as centre, strike the curve *a b c* (fig. 4); now take the length of the curve *a* A *c* (fig. 1), and

mark off a corresponding distance from *a b* to *c* (fig. 4), draw the chord from *a* to *c* (fig. 4). In fig. 3 draw a line from the centre *i* to B on the curve ABC, and take the length of the chord *a c* in fig. 4, marking off an equal distance from *a* to *c* (fig. 3) on the curve ABC. Take the distance from *a* to *d* (fig. 4), and from *a* (fig. 3) mark off the point *d* on the line *i* B; with *d* as centre (with the same radius as the curve *a b c* is struck by) strike the curve *a b c* (fig. 3), take the distance *c b* (fig. 1), which is the straight part of the side, and mark off on fig. 3 from *a* to *e* and *c* to *f* on the circle ABC, draw lines from *e a c* and *f* to the centre *i*, take the distances from B to *c* or B to *a*, marking off the same distance from *e* to A and *f* to C, draw lines from the centre *i* to A and *i* to C, and produce them as at *k* and *l*: with radius *i d* draw the circle as dotted *g d h*, take *g* and *h* as centres with radius *d b*, and strike the curves from *f* to *k* and *e* to *l*, draw lines *a e* and *c f* from the highest part of the curves, which will make them tangent, and the base of the pattern will be finished.

To get the curve for the hole in the top, bisect the lines *a e* and *c f* (fig. 3) through the centre *i*, and produce them indefinitely as *n* and *m*, from *r* on the circle (fig. 1) draw a line *r p* at right angles with CD, take the up-

right depth as EF, and mark a like distance from r to p. Draw $p\,m$ at right angles with $r\,p$, take the distance from $k\,l$ (which shows the slant of the end), and mark off a corresponding distance from p to m, take the distance from r to D (being the slant of the side) and mark off a corresponding distance from p to n on the line $p\,m$, draw line from points $m\,r$ to cut the centre line AB at s, also draw line from points $n\,r$ to cut the centre line at t, take the distances from m to r or h to c, and mark off like distances from b to r, l to x, and k to v (fig. 3), being the slanting depth of the end of the pattern. Take the distance from s to r (fig. 1), and from r (fig. 3) mark off the point o, and from v the point s, and from x the point t; using $t\,o$ and s as centres strike the curves $x w$, $v\,u$, and $p\,r\,q$, with the radius $s\,r$ (fig. 1). Now take radius $t\,r$ (fig. 1), using m and n as centres, strike the curves $w\,q$ and $p\,u$, which will complete the pattern required.

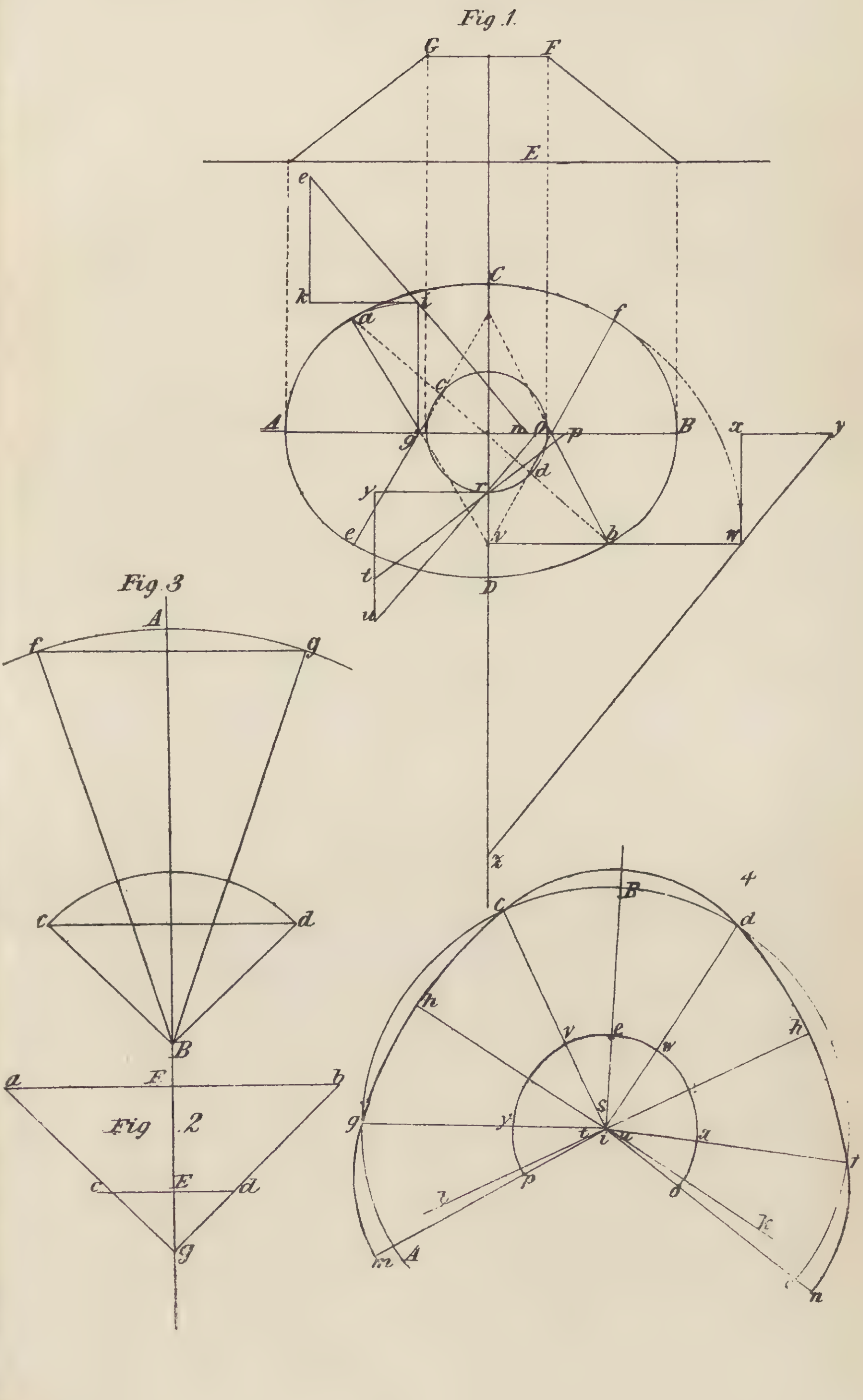
PLATE XIV.

To describe the pattern for a Tapering article, oval at the base and round at the top,

(Such as an oval Canister Top, having a round hole for the neck and cover).

Fig. 1 represents the plan and elevation of the top required. Take AB and CD, being the given diameters. Draw a diagonal line from the points *a* and *b*, being the sectional points of the curves; make the line *a b* (fig. 2) equal to *a b* (fig. 1). Now take the distance from F to E (fig. 1), and mark off a like distance from F to E (fig. 2), draw *c d* parallel to *a b*, make *c d* (fig. 2) equal in length to the diameter of the circle from *c* to *d* (fig. 1). Draw *b d* and *a c* to cut the perpendicular line at *g*, with radius *g b* from centre *i* strike the circle AB*c* (fig. 4), or boundary line; *v* being the centre from which the curve *a* C*f* is struck, draw line *v w* at right angles with CD, and extend the curve *a* C*f* as dotted to cut the line *v w*. Draw *w x* at right angles with *v w*, take the upright height EF and mark off from *w* to *x*, draw *x y* at right angles with *w x*, take the distance from D to *r*, being the flue of the

Plate 14.



side, and mark off a like distance from x to y; draw line from y and w to cut the perpendicular CD at z. Draw a perpendicular line as A B (fig. 3); taking B as centre, with radius $z\,w$ (fig. 1) strike the curve $f\mathrm{A}g$ (fig. 3). Take the length of the curve from C to f (fig. 1), and like distances from A to g and A to f (fig. 3). Draw lines from f and g to the centre B, and draw line $f\,g$, which will give one section of the base of the pattern.

The curve of the end of the base being struck from g (fig. 1) as centre, draw line from g at right angles with AB, and extend the curve e a to cut the line produced from g to i. Draw line $i\,k$ at right angles with $i\,g$, making $i\,k$ equal the upright height, as EF. Draw $k\,e$ at right angles with $i\,k$, make k to e equal the flue of the end, as from A to g, or the distance from the curve of the oval to the circle on the line AB.

Draw line from points e and i to cut the centre line AB at n, now with radius $n\,i$ from B (fig. 3) as centre, strike the curve $c\,d$, take the length of the end curve from e to a (fig. 1), and mark off a like distance as from c to d (fig. 3), draw chord line $c\,d$, which will give the end section of the base.

Take the distance from c to d (fig. 3), and mark off an equal distance on the circle ABC

(fig. 4) as from *c* to *d*, and draw lines from the points *c* and *d* to the centre *i*, bisect these lines by the perpendicular B *i*, take the distance from either B to *d* (fig. 3) or *n* to *i* (fig. 1) as radius, and from *c* or *d* (fig. 4) mark off point *e* on the line B *i*, with *e* as centre, strike the curve *c d*. Take the distance from *f* to *g* (fig. 3), and mark off a like distance on the circle or boundary line from *c* to *g* (fig. 4), and *d* to *f*. Draw lines from *g* to the centre *i*, and from *f* to *i* bisect the distances from *g* to *c* as at *h*, and from *d* to *f* at *h*, extend these lines as *k* and *l*. Take the distance from *z* to *w* as radius (fig. 1), and from *d* (fig. 4) mark the point *l* on the line *h l*, and from *g* mark off the point *k*. Using *l* and *k* alternately as centres, strike the curves *d f* and *c g*. Take the distance from *d* to B, and mark off from *g* to A and *f* to *c*, and draw lines from the centre *i* to A and *c*. Again using *n i* (fig. 1) as radius, strike the curves *f n* from a centre on the line *n i*, also from a centre on the line *m i* strike the curve *g m*, which will complete the curve for the base.

Now to describe the curve for the circular hole in the top: the line CD being drawn through the centre by which the circle is struck, from point *r* draw *r y* at right angles with the diameter line CD, take the distance

EF, being the upright height required, and mark off the same distance from *r* to *y*, draw the line *y* to *u* at right angles with *r y*, take the distance from D to *r*, and mark off from *y* to *t*, being the slant of the side. Draw line from points *t r* to cut the diameter line AB at *p*, then take the distance from the oval to the circle, as from A to *g*, being the slant of the end, and mark off a like distance from *y* to *u*, draw line from *u* and *r* to *o* on the line AB, take the distance from *u* to *r* or from *e* to *i*, which should be the same, being the slanting depth of the end, and mark off like distances from *n* to *o* (fig. 4), from *m* to *p*, and from B to *e* (the outer curve). Take the distance *o r* (fig. 1) as radius, making *s* (fig. 4) as centre on the line B *e*, and strike the curve *v e w* through the point *e*; with the same radius strike the curve *o x*, with *u* as centre on the line *c i*; also with *t* as centre on the line *m i*, strike the curve *p y*; with radius *p r* (fig. 1) strike the curves *y v* (fig. 4) and *w x*, with centres found on the lines *h k* and *h l*, which will complete the pattern required.

PLATE XV.

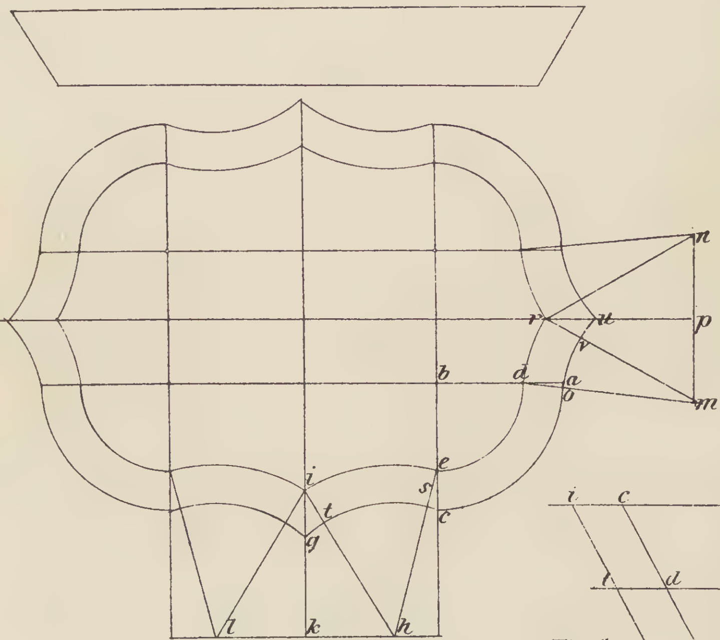
To strike a pattern for the Tapering Sides of a Tray having various curves.

Fig. 1 shows the plan and elevation of the article, for which a pattern for the tapering sides is required. Having drawn the plan, it is required to show the points or centres from which the various curves are struck, as shown here by *n m*, *b h*, and *l*. The tapering being equal on all sides, the curves for the bottom and top are struck from the same centre, that is, the curves *i e* and *g c* are both struck from one centre, viz., *h*.

To prepare for the development of the pattern construct fig. 2, making the distance from A to *b* the required upright height (fig. 1), and take the radius by which the curves *a c* and *d e* are struck, that is the distance from *b* to *a* and *b* to *d*, and mark off the same on fig. 2 from A to *c* and from *b* to *d*; draw the line from points *c* and *d* to cut the perpendicular at *e*, also the distance *h e* or *h i*, and mark off the same from A to *i* (fig. 2), and the distance from *h* to *t* mark off from *b* to *t* (fig. 2). Draw a line from points *i* and *t* to *k*. (The radius

Plate. 15.

Fig. 1.



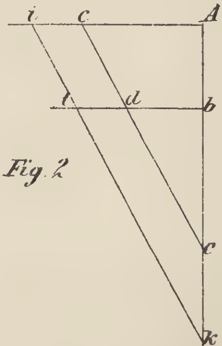
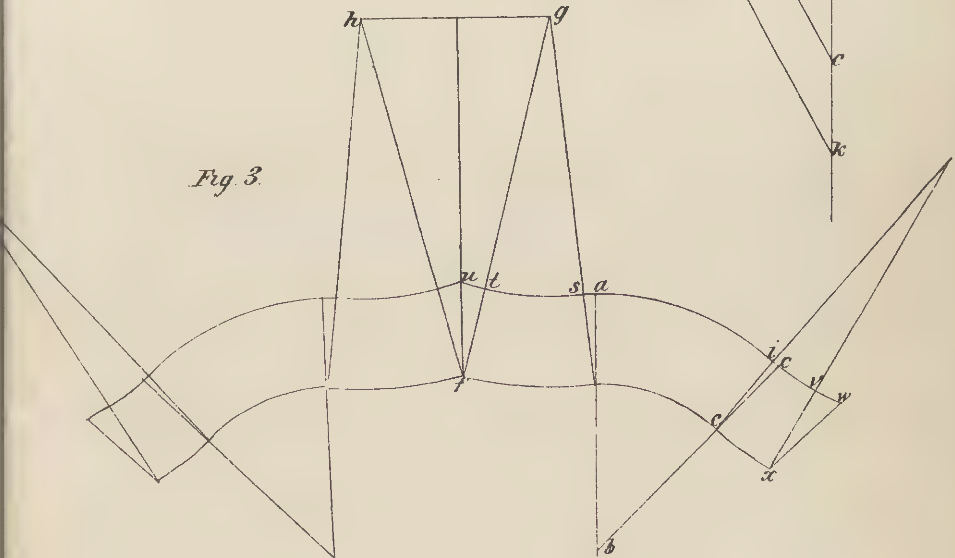


Fig. 2

Fig. 3.



m r, and *m v*, in this case, being the same as from *h* to *i* and *h* to *t*, do not require to be transferred to fig. 2.)

To commence describing the pattern take *e c* (fig. 2) as radius, and from *b* as centre describe the curve *a c* (fig. 3), and take the length of the curve from *a* to *c* (fig. 1) and mark off a corresponding distance from *a* to *c* (fig. 3), and draw lines from *a* and *c* to the centre *b*. Now take the radius from *e* to *d* (fig. 2), and again using *b* as centre (fig. 3) strike the curve from *e* as far as the line *a b*. Take the distance from *a* to *o* in fig. 1, and mark off the same from *c* to *i* (fig 3), likewise the distance from *c* to *s* (fig. 1); and take a like distance from *a* to *s* (fig. 3), and draw lines through the points thus received from the points where the curve *e* intersects the lines *a b* and *c b*, and produce them indefinitely as *s g* and *i k*.

Note.—In further describing the pattern the letter *d* will be used, it ought to have been placed on the line *a b*, as *e* on the line *c b*.

Take the radius *k i* (fig. 2), and from the curve *e* (fig. 3) mark off the point *k* on the line *e i*, also from *d* the point *g* on the line *d s*; using *k* as centre strike the curve *e x*, and from *g* as centre strike the curve *d f*. Again from *k* and *g* as centres, and radius *k t* (fig. 2), strike the curves *a u* and *i w*, take the length of curve

from d to r (fig. 1) and mark off a corresponding distance from e to x (fig. 3) and draw the line $x\,k$; the distance $v\,u$ in fig. 1 will show what is required to be added on the curve from v to w in fig. 3; and draw the line $x\,w$, which will give one end of the pattern to meet for joining at $r\,u$ (fig. 1). Now take the length of the curve from e to i (fig. 1) and mark off a corresponding distance from d to f (fig. 3). Draw line from f to the point g, mark off the distance from t to u equal to t to g (fig. 1) and draw line from points f and u (fig. 3) and produce it indefinitely as far as $g\,h$. Draw line from g to h at right angles with the line from f and u, make the distance from centre line to h equal it at g, which will be the centre for the next curve, and proceed in like manner to complete the pattern.

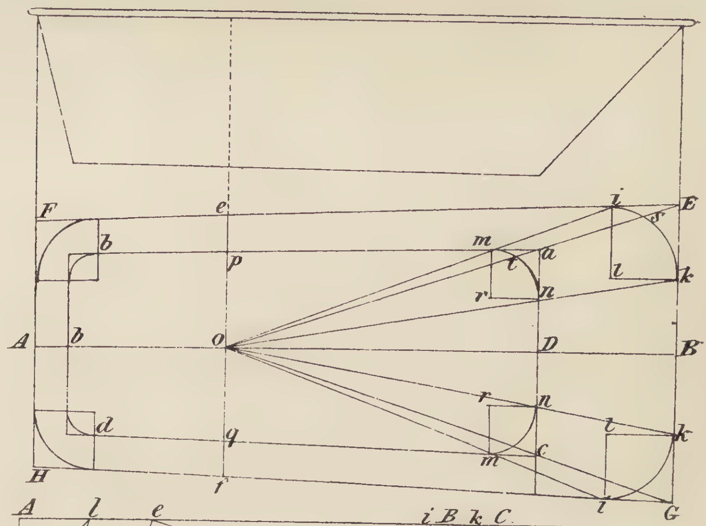
PLATE XVI.

To strike the pattern for an Oblong Tapering Bath.

Fig. 1 represent the elevation and plan for the bottom and top, showing a much greater slant or fall at the head than at any other part.

Plate. 16.

Fig 1.



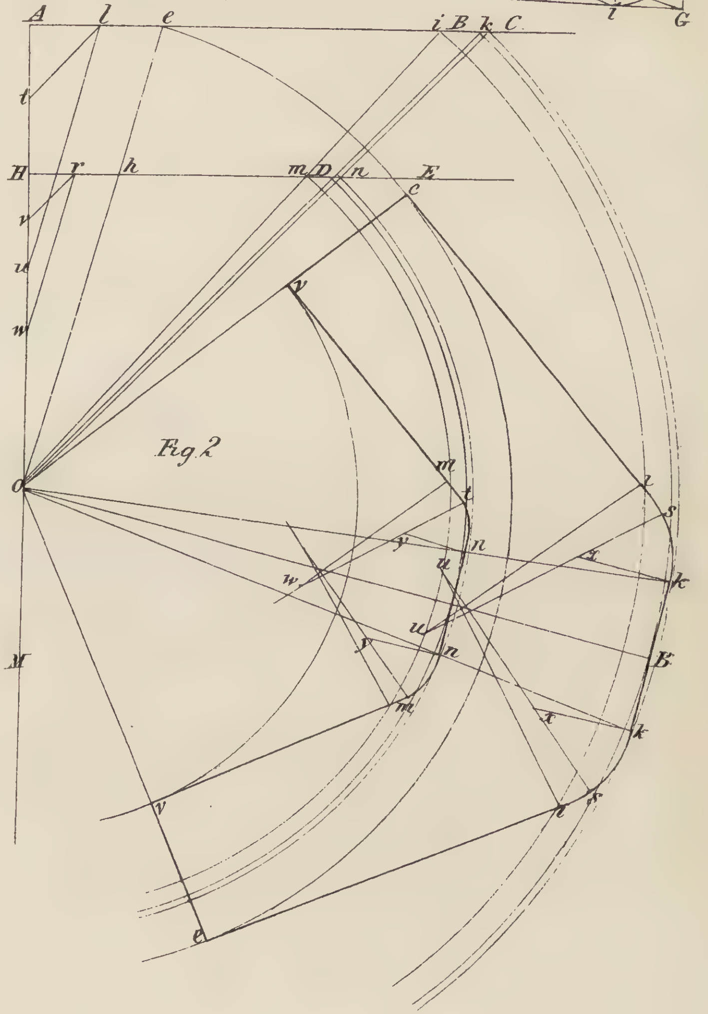


Fig. 2

Having drawn the lines FE, HG, FH, and E G, which represent the size of the article at the top, draw also four similar lines, which represent the size and position required for the bottom. Draw the diameter line AB, and draw lines from the angles in the top and bottom as from E and *a*, G and *c*, and produce them to meet the centre line AB, as at *o*. Draw the corners as *i k*, and draw lines from *i* and *k* to the centre *o*; where they cut on the lines *a b* and *a c* will show proportionate corners for the bottom (these corners being quarter-circles, are struck from *r* and *l* as centres). Draw a line *e f* through the point *o* at right angles with AB.

To proceed with fig. 2 where the pattern has to be developed. Draw the perpendicular AM, take the upright height from A to H and draw AC and HE at right angles with AM. Take the length of the lines from O to B, O to *k*, O to *i*, and O to *e* (fig. 1), and from A (fig. 2) mark off the points B *k i* and *e*. Again in fig. 1 take the distances OD, O *n*, O *m*, and O *p*, and from H (fig. 2) mark off corresponding distances at D, *n*, *m*, and *h*. Draw the lines from points B and D to cut the perpendicular line at O, also the lines from *k* and *n*, *i* and *m*, *e* and *h*, which will also cut the perpendicular at O.

Take the radius of the large corner, as *l i* (fig. 1), and mark off the same from A to *l* (fig. 2), also the radius of the small corner *r n*, and mark off the same from H to *r*. Draw the lines from *l* to *t* and *r* to *v* parallel with the line B D O, also the lines from *l* to *u* and *r* to *w* parallel with the line *e h*.

With O as centre draw curves from the points on the line A C, that is from *k* B *i* and *e*, also on the line H E from points *n* D *m* and *h*. Draw the line B O (fig. 2), and from B mark off to *k k* the same distance as the corresponding letters in fig. 1, draw lines from *k* to O, also a line from *k* to *k*. Now from where the lines *k* O intersect the curve *n*, draw line as from *n* to *n*, and draw perpendicular lines from points *n* to *y*, likewise from *k* to *x* take the length of the line *t l*, and from *k* mark off the point *x*; from *x* as centre, radius *t l*, strike the curve *k s* on each side, taking the length of the curve from *k* to *s* (fig. 1) mark off the same distance from *k* to *s* (fig. 2), draw line from *s* through the point *x* indefinitely, take the length of the line *u* to *l*, and from *s* mark off the point *u*; using *u* as centre with radius *u l* strike the remainder of the curve from *s* to *i*.

Taking the distance from *i* to *e* (fig. 1), mark off a like distance from *i* to *e* (on the curve *e*

fig. 2), draw lines from i to e, also from e to the centre O. With radius $v\,r$, from n mark off the point y for a centre, and strike the curve $n\,t$, making it the same length as $n\ t$ (fig. 1): draw line from t through the centre y, and produce it as to w, taking the distance from w to r as radius, and from t mark off the point w for a centre, and strike the remainder of the curve from t to m to meet the curve drawn from m on the line HE. Draw line from m to cut the line eO as at v on the curve h: this will complete the pattern of the head, and the part of the body shown at the line $e\,f$. The remaining portion (or toe) being about equal tapering, can be obtained in the same manner as an ordinary oblong article which is fully described in Plate VII.

Note.—The tapering at the end being so much more than that of the sides it becomes necessary to strike the corners in the pattern in two sections as divided by the line E a O, the end section being struck in proportion to the slant of the end, and the remainder in proportion to the slant of the side.

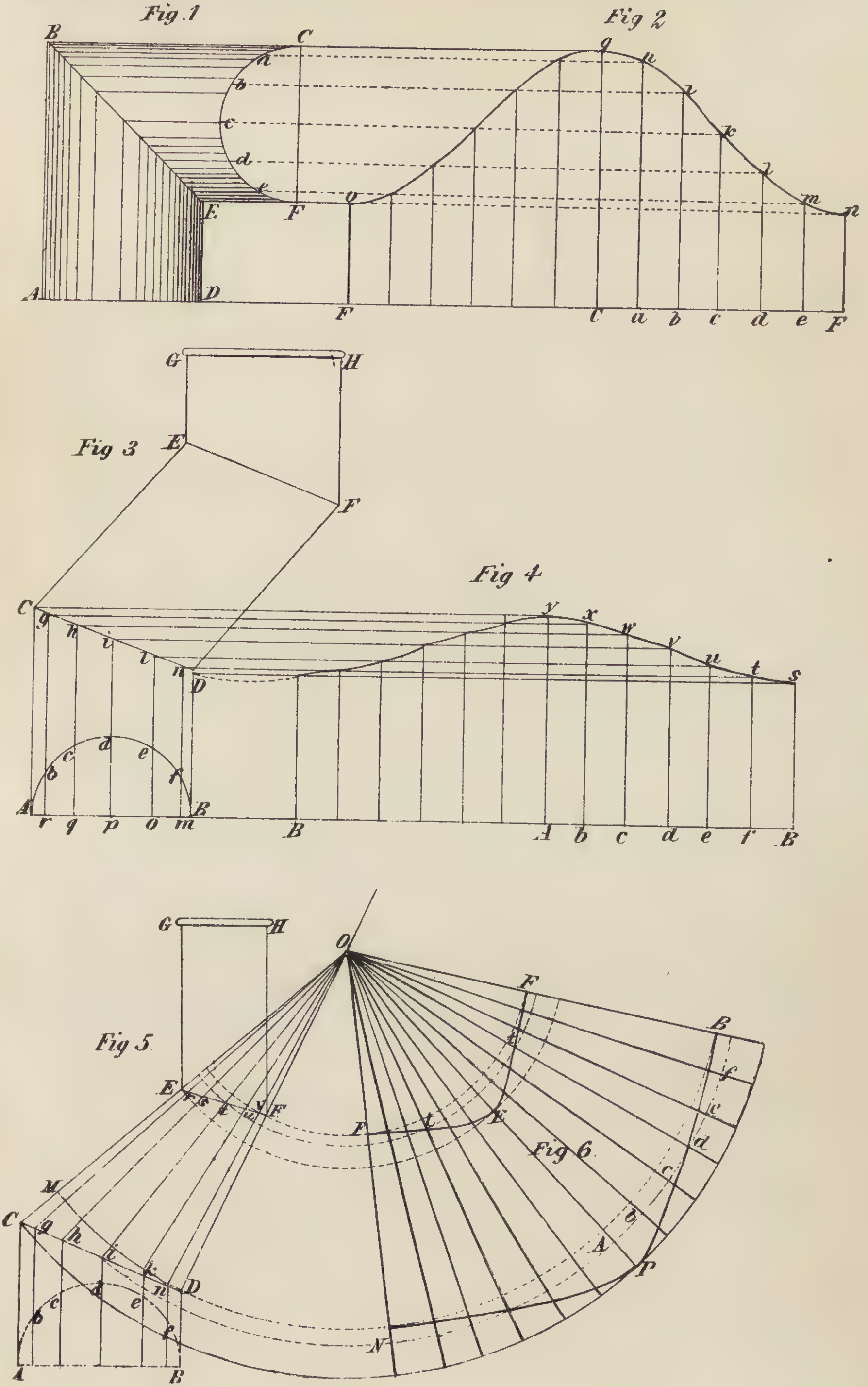
PLATE XVII.

To strike the pattern of an Elbow at right angles, in a Round Pipe.

Draw ABCDE and F (fig. 1), which shows the size of the elbow required. Take the centre on the line CF, and strike a semicircle the size of the cylinder. Divide the semicircle into any convenient number of equal parts, as *a b c d e* and F, extend the line AD indefinitely, and take twice the number of parts as there are on the semicircle (fig. 1) as shown from C to F (fig. 2), on each side of the centre C, and draw perpendicular lines from F *n*, *e m*, *d l*, *c k*, *b i*, *a h*, C *g*, &c. Extend the line BC to cut the perpendicular C *g*, and draw lines from the points in the semicircle *a b c*, &c., to cut the perpendiculars as at *h i k*, &c.

Draw a curve line from all the points of intersection, as *m n l*, &c., to *o*, which forms the curve required for the pattern. This curve should, from *n* to *m*, commence somewhat at right angles with the perpendicular *n* F, also at *h* to *g*, to give a curve, and not to show a point at *g*.

Plate 17



To strike the pattern of an Elbow in a Round Pipe at any angle required (in this case, an obtuse angle).

Draw ACEG and BDFH according to the angle required in the pipe. Draw the section line CD from the two points of the angle, showing where the joint is required. Extend the line AB indefinitely. Draw the semicircle the size of the cylinder, divide it into a convenient number of parts, as *b c d e f* B, and take a corresponding number of points from B to A, and from A to B, as *b c d e f*. Draw the perpendiculars B *s*, *f t*, *e u*, &c. Now through the points *b c d*, &c., on the semicircle, draw the perpendiculars *g r*, *h q*, *i p*, *l o*, and *n m*. Either take the length of the lines as AC, *r g*, and *q h*, &c., and mark off the same lengths from A to *y*, *b* to *x*, *c* to *w*, etc.; or draw lines parallel to AB from the points on the section line, as *g h i*, etc., to intersect the perpendiculars, as at *y x w*, and draw a curve from these points of intersection, as *s t u v*, &c., which will give the pattern required.

To strike the pattern of a Tapering piece of Pipe to join Two Upright Cylinders, to form a Double Elbow.

Draw A C, E G, and B D, F H (fig. 5) according to the plan required: produce the

line C E and D F until they meet at the point O. Draw the semicircle and divide into equal points as *b c d e f*, and draw the perpendiculars through these points to cut the section line C D as at *g h i k n*, from these points draw lines all leading to the point O. With O as centre, radius O *i*, draw the curve N A, (fig. 6), and extend it indefinitely; with the same compass set as divided the semicircle into six parts on the curve N, mark off twelve points from N to B, and draw lines from these points to the centre O. With radius OC strike the curve C P, and with radius OD strike the curve DB.

If curves were drawn with O as centre from the points *g h k* and *n*, which are not shown here, the points of intersection would give the exact direction of the curve BPN, and curves drawn from the same centre from the points of intersection on the line EF (fig. 5), the points of intersection (fig. 6) will give the direction of the curve F *t* E *t* F, which will give the pattern for the tapering part of the angular pipe. The other parts can be drawn as previously described.

NOTE.—The curves mentioned which give the pattern should be drawn from the various points with free hand. As there are many curves in geometry and in mechanical drawing which are drawn better by hand from given points than by instruments, the student is recommended to practise free-hand drawing at the same period that he studies other portions of mechanical art.

PLATE XVIII.

To strike the pattern for a T-piece, or to join two cylinders at right angles.

Strike a semicircle the size of the smaller cylinder (fig. 1) from E to F, also extend the lines DC and AC as shown at M and *q*, and describe a quadrant with the same radius as the semicircle is struck by. Now divide the semicircle into a convenient number of parts, in this case six, as *g h i k n* and F, divide the quadrant into three equal parts, as *o p q*, also strike a semicircle from C to D the size of the larger cylinder, and draw perpendiculars from *o p* and *q* to cut the curve in the larger cylinder, as at *r s* and *t*. Now draw lines from the points *r s t* parallel to CA, and draw also perpendiculars from points *g h i k n* to intersect the horizontal lines *r s t*; those points of intersection, as *u v w x y* N, will show the course of the curve generated by the smaller cylinder being fitted against the larger one at right angles.

Now draw twelve perpendiculars as shown in fig. 2, as F *e d*, &c., and take the lengths in fig. 1 from FN, *e y*, *d x*, *c w*, *b v*, *a u*, EM, and

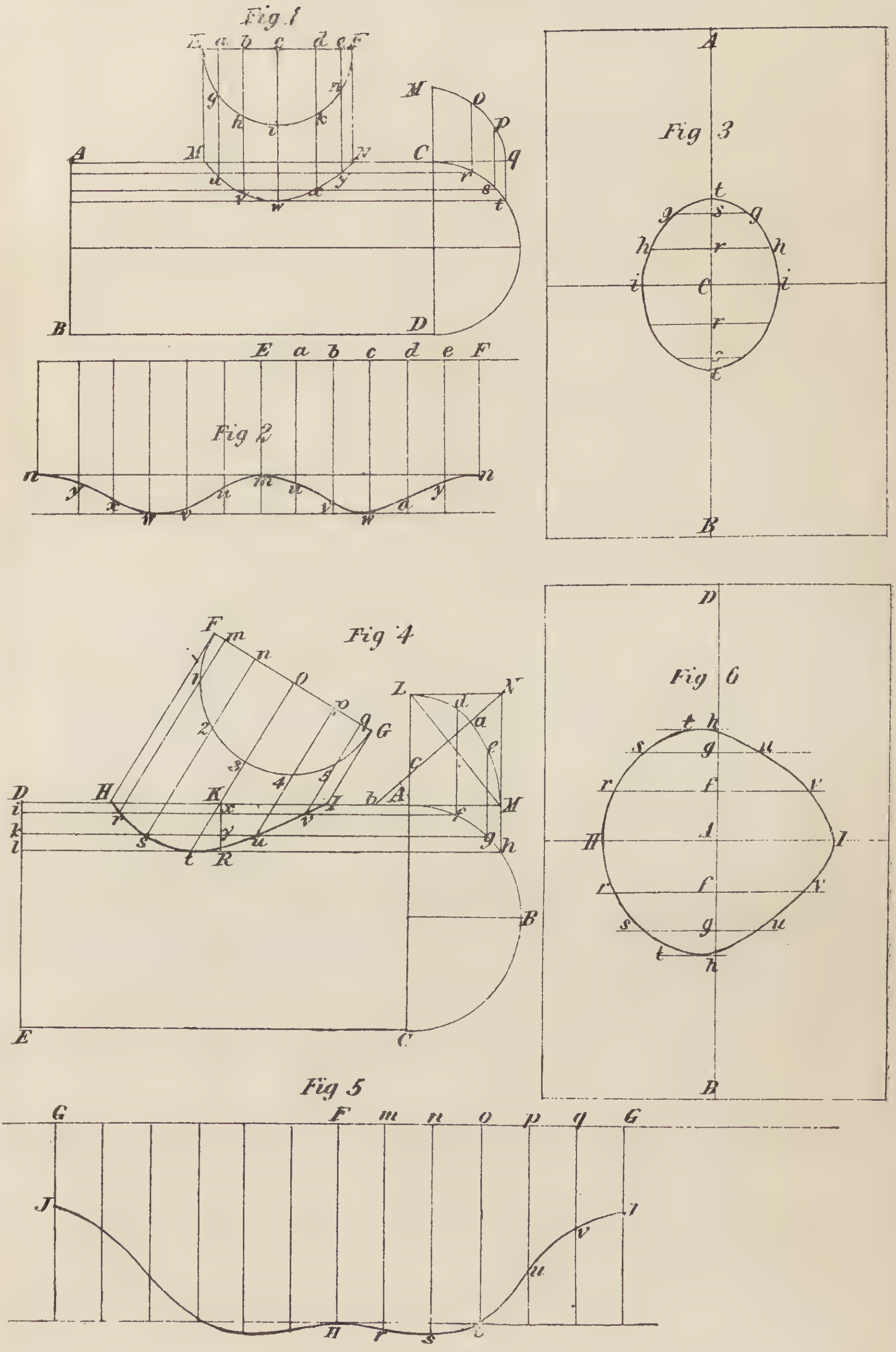
transfer the same to the corresponding letters in fig. 2, and draw a curve from these points, which will give the pattern for the smaller cylinder.

Next, to obtain the hole to receive the smaller cylinder, proceed in fig. 3 to draw the line AB, and bisect it at C, take the distances from C to *r*, C *s*, and C *t* (fig. 1), and mark off on each side of C (fig. 3) like distances shown by the corresponding letters, and through these points draw lines *h h* and *g g*, &c., at right angles with AB. Take the distance from *c* to *i* (fig. 1) and mark off a corresponding distance on each side of C to *i* (fig. 3); also the lengths *b h* and *a g* (fig. 1), and transfer the same to fig. 3, on each side of *r* to *h*, and each side of *s* to *g*; a curve drawn from these points will give the required aperture to receive the smaller cylinder.

To strike the pattern of Two Cylinders for joining at an Oblique Angle (or slanting direction).

DA and EC (fig. 4) represent the larger cylinder, and let HF and IG be drawn the required size of the cylinder that has to be connected to it at any angle or position required. Draw line FG at right angles with HF, and describe the semicircle from F to G, and

Plate.18.



divide it into six equal parts, as 1, 2, 3, &c., draw lines through these points at right angles with FG, now strike the semicircle ABC representing the size of the larger cylinder, and extend the lines DA to M, and CA to L, take the radius of the semicircle, as *o* F or *o* G, and from A mark off the same distance to M, now take half the length of the base of the cylinder, as from K to H or K to I, and mark off a like distance from A to L. Now, instead of drawing a quarter-circle as required in fig. 1, where the cylinders meet at right angles, here a quarter of an ellipse is required, as shown from L to M, the radius of which may be obtained in the following manner: Draw line from M to N, also from L to N at right angles, and draw the diagonal line LM; draw a line from the point N to cut through the diagonal LM at right angles, producing the points *c* and *b*: with *c* as centre, radius *c* L, draw the curve from L to *a*; with *b* as centre, radius *b a*, draw the remainder of the curve from *a* to M. Divide the curve from L to M into three equal parts, and draw perpendiculars from these points to meet the curve AB, as *d f*, *e g*, M*h*; draw also lines parallel to AD from *f* to *i*, *g* to *k*, and *h* to *l*: where those lines are intersected by the lines drawn through the smaller cylinder, will be the points from which to trace the curve, as *r*

s t u, &c. Draw twelve perpendicular lines in fig. 5, as F *m n o*, &c., the same distances apart as the divisions in the semicircle (fig. 4), and take the length of the lines in fig. 4, as FH, *m r*, *n s*, &c., and transfer the same to the perpendiculars in fig. 5 marked by the corresponding letters. Draw a curve from the points thus obtained, as from J *v u*, etc., which will give the pattern for the smaller cylinder.

To obtain the curve for the hole in the larger cylinder. Draw DB and HI (fig. 6) at right angles, take the distances from A to *f g* and *h* (fig. 4) and mark off like distances on each side of A on the line DB, as *f g h*, and draw lines from these points parallel to HI. Draw a perpendicular from point K to R (fig. 4) and carry the length of KH and KI (fig. 4) from A to H and A to I (fig. 6), also the distances *x r* and *x v* (fig. 4) from *f* to *r* and *f* to *v* (fig. 6) from *y* to *s* and *y* to *u* (fig. 4). Transfer to fig. 6 from *g* to *s* and *g* to *u*, take the distance from R to *t* (fig. 4) and mark off the same from *h* to *t* (fig. 6), the curve drawn from the points thus obtained will give the aperture required to receive the smaller cylinder.

PLATE XIX.

To strike the pattern for a Lobster-back Cowl.

Describe the semicircle from E to F (fig. 1) any given size, and divide it into a convenient number of parts, as 1, 2, 3, etc., through those points draw perpendiculars to meet the line O B, taking O as centre describe the curve BHA, also let curves be drawn from all the perpendiculars, as 1, 2, 3, &c. Divide the curve from B to A into as many parts as sections required, in this case four, as shown at KHGA, draw a line from O to *p* through the centre of one of these sections, and draw straight lines from the points on the curve where intersected by the lines HO and KO, as *a b*, *c d*, *e f*, *g h*, etc. Mark off twice the number of points as are contained on the semicircle and the same distance apart, on the line E (fig. 2) as 1, 2, 3, 4, etc., from *p* to H and K (fig. 1) mark off the same distance from E to H and K (fig. 2), from *s* to *a* and *b* (fig. 1) mark off the same distance from 7 to *a* and *b* (fig. 2), also the distance from *t* to *c* and *d* (fig. 1) mark off a like distance from 6 to *c* and *c* (fig. 2), and so

on with the remaining distances in fig. 1, which are marked with corresponding letters in fig. 2. A curve drawn from the points thus obtained will give the development of one section, which, as the four sections are alike, will render further explanation unnecessary.

To strike the pattern for a Round Pipe, to form a Semicircle for connection to other pipes.

Draw the semi-circle from *f* to *c* (fig. 3) which represents the size of the pipe, divide it into a convenient number of equal parts, as 1, 2, 3, 4, 5 *c*, and draw perpendiculars from these points, as from 1 to *g*, 2 to *h*, 3 to *i*, etc., and from *g h i k* and *l* draw the semicircles, now divide the curve *a b c* into a convenient number of parts, showing the number of sections the pipe will be composed of, take one of those sections as from *a* to *m*, and bisect it at *t*, draw a line from *t* to the centre *o*, and draw straight lines from where the curves intersect the lines *m o*, and *a o*, to connect those points shown from *m* to *a*.

Draw the horizontal line (fig. 4) as *f g*, and on this line take twice the number of distances as there are on the semicircle (fig. 3) 1, 2, 3, 4, 5, *c*, and take the distances from *t m*, *u n*, *v o*, etc., (fig. 3), and carry the same on each

Plate 19.

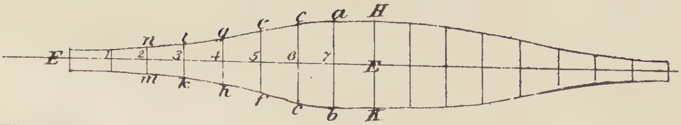


Fig. 2

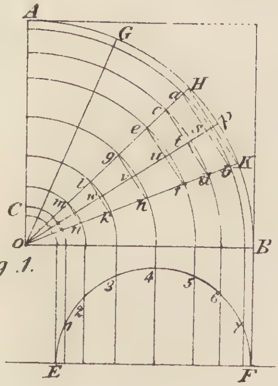


Fig. 1.

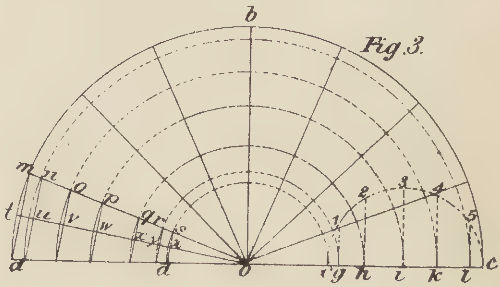


Fig. 3.

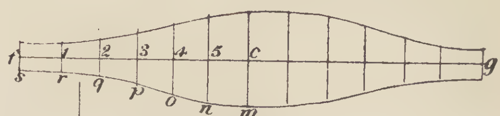


Fig. 4

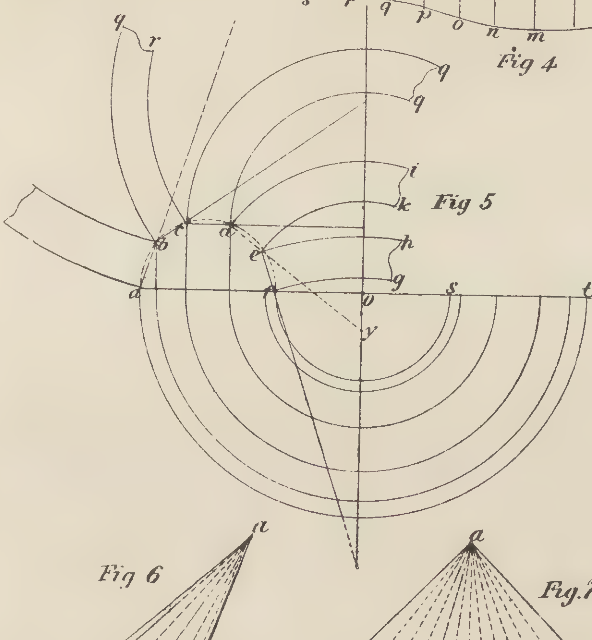


Fig. 5

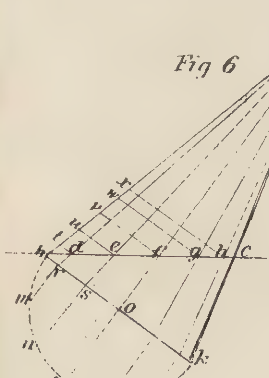


Fig. 6

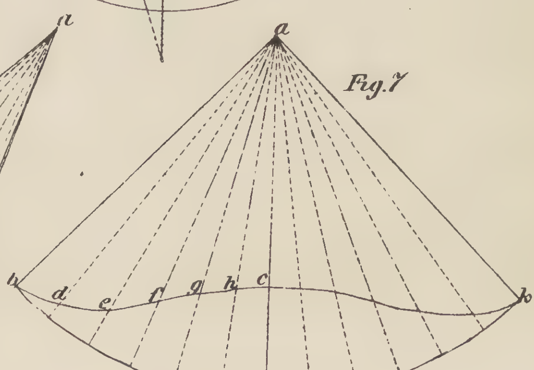


Fig. 7

side of the centre line *f g* (fig. 4) from *c* to *m*, 5 to *n*, 4 to *o*, etc. A curve drawn through the points thus obtained will give the pattern for one section.

Fig. 5 also shows a semicircular pipe, but the joints of the various pieces of which it is composed will run in an opposite direction.

Draw the semicircle from *a* to *f*, showing the size of the pipe, and divide it into a convenient number of equal parts, as *a b c d e f* and draw a line perpendicular to the base of the semicircle *a t*, and from the points *a b*, *b c*, *c d*, etc., draw lines to cut the perpendicular drawn through the centre, these points used as centres, and the corresponding points on the semicircle from which they are produced will give the radii for the various curves of which the pipe is required to be made.

Fig. 6. To develop the pattern of a cone cut oblique to its base: *b a* and *b k* represent a right cone, the line *b c* represents the oblique direction of the base required, draw the lines *a b* and *a c* to *k*, and from *o*, the centre, strike a semicircle *b l k*, divide it into six equal parts as *m n l p q*, and draw perpendicular lines from these points to cut the line *b k*, as at *r s o*, etc., from the points thus received on the line *b k*, draw lines to the apex *a*, where they are in-

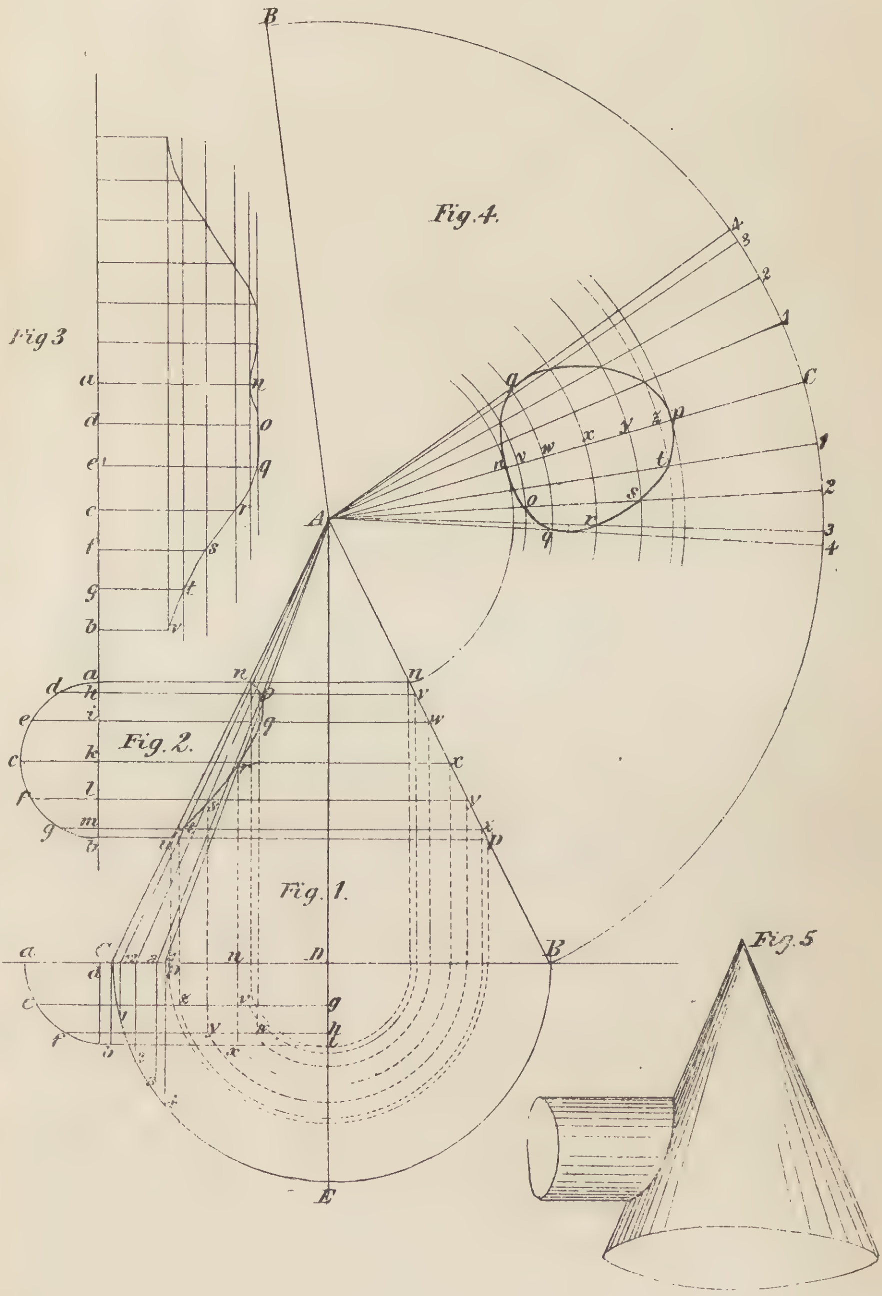
tersected by the line *b c*, draw lines parallel with *k b*, from *d* to *t*, *e* to *u*, *f* to *v*, etc. Now take the distance from *a* to *b* as radius, and in fig. 7, using *a* as centre, strike the curve *b o k*, with the same distances as the semicircle is divided by fig. 6, take twice the number of points in fig. 7 from *b* to *k*, and draw lines from those points to the centre *a*, as *b d e f*, etc. Now take the distance in fig. 6 from the centre *a*, to *t u v w* and *x*, and mark off the same from the centre *a* in fig. 7 to *d e f g* and *h*; also on the other side of *c*; now a curve drawn from these points will give the pattern required.

PLATE XX.

To describe the pattern for a Cone and Cylinder, to intersect or meet at right angles with their axes.

Fig. 5 is a (small) representation of the cone having a cylinder joined to it at right angles with its axis. The patterns which are required to be described, being first, the development of the cone, secondly, the curve of the cylinder, to fit when placed against the cone, and thirdly, the shape required for the hole or

Plate 20.



aperture in the cone to receive the cylinder (or to meet edge to edge for joining). Fig. 1. CB shows the base, and DA the elevation of the cone. Draw the lines AC and AB, from centre D strike the semicircle CEB. Now to develop the pattern of the cone, take A as centre, radius AB, and strike the curve BCB (fig. 4), find the length of the curve BEC (fig. 1), and take twice that length from BCB in fig. 4.

The next problem is to find the curve which will be generated by the intersection of a cylinder (which is a round body of equal diameter) with the cone (which is a round body of ever decreasing diameter). The lines *a n* and *b u* (fig. 2) represent the size of the cylinder, draw the semicircle and divide it into equal parts, as *d e c f g b*, and from these points draw lines parallel to *a n* to cut the line AB, and from these points *n v w x y z p*, draw perpendicular lines as dotted to cut the base line BC. Next from C draw the perpendicular line C *b*, and take half the length of the line from *u* to *n* (fig. 2), which will be where it is intersected by the line *c x*, and carry the same from C to *a* (fig. 1) and take the radius of the semicircle *k* to *c*, and mark off the same from C to *b*, and describe the curve *a b*. Divide it into half as many parts as the semicircle has been divided

into (but the distances will not be the same) and from these points draw lines *e g*, *f h*, and *b i* parallel to CD. Now using D as centre strike the curves from the dotted lines drawn from the points *p z y*, etc., to meet the horizontal lines just drawn in rotation as follows, join the perpendicular drawn from *p* on the line AB with a curve, and extend it to *p* on the line *a* CD and raise a perpendicular from *p* to *u*. Next from the perpendicular brought down from *z*, draw a curve to meet the line *e g* at *z*, and raise a perpendicular from *z* to *t* cutting the line *g z*, and from the line brought down from *y* strike the curve to meet the line *f h* at *y*, and raise a perpendicular to cut the line *f y* as at *s*, and from the line *x* strike the curve *x* to meet the line *b i*, and raise the perpendicular to meet the line *c x* as shown at *r*. The other curves *w v* and *n* follow back in the same manner on the lines *f h*, *e g*, and CD producing the points *q o* and *n* (fig. 2). The points *u t s r q o n* will show the course of the curve sought.

By drawing the horizontal lines *b g f c e d a* (fig. 3) the same distance apart as the corresponding letters on the semicircle (fig. 2), and by producing the perpendiculars from *n o q r s t u* to intersect the horizontal lines drawn in fig. 3, the points of intersection will show the

course of the curve for the pattern of the cylinder.

Now to find the shape of the aperture in the pattern of the cone. First draw the line AC (fig. 4), and taking A as centre, with radii A *n*, A *v*, A *w*, etc. (fig. 1), describe the arcs as *n v w x*, etc., (fig. 4). Now from A draw lines through the points *t s r q o*, to cut the line CD at 1 2 3 4, and from these points draw perpendiculars to cut the curve CE at 1 2 3 4. Take the distance C 1, C 2, C 3, and 4, on the curve CE, and from C (fig. 4) mark off the same as shown by corresponding figures. Draw lines from these figures to A, the points of intersection will give the course of the curve. The line drawn from A through *o*, also cuts through point *s*, being line 2; so, observe in fig. 4 the points *o* and *s* are the required points for the curve on the same line 2.

Note.—The distance from *a* to *d* being the same as from C to *b*, the distance between the lines *d* and *b* shows that the required curve from *a* to *b* is more than a quarter-circle, therefore it should be a quarter of an ellipse, as in fig. 4, Plate XVIII.

PLATE XXI.

To describe a Cylindric Section through any given angle.

Let AB (fig. 1) be a section of a right cylinder, and CD the line of the required section. Draw the circle at AB, and on the arc take any number of points, as 1 2 3 4, etc., from which draw lines perpendicular to AB, produced to cut the line CD in 1 2 3 4, etc. From those points draw the lines 1 *a*, 2 *b*, 3 *c*, 4 *d*, etc., perpendicular to CD, and make these ordinates respectively equal their corresponding points on its base, that is to say, let *d* 4, *c* 3, etc., on its base equal 4 *d*, 3 *c*, etc., on the line of its required section; continue this process throughout, and through the points found in this way will be the required section.

Note.—This problem will also show that a round cylinder being cut oblique to its base, the surface so cut becomes an ellipse, hence the reason for requiring a quarter of an ellipse to be placed on the larger cylinder in fig. 4, Plate 18, to be divided, and produce lines to meet corresponding lines coming from a cylinder placed in an oblique direction.

Plate. 21.

Fig. 1.

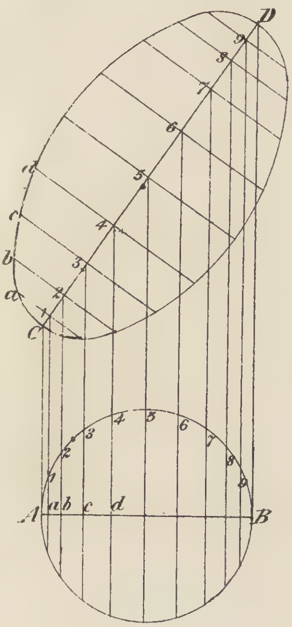


Fig 2.

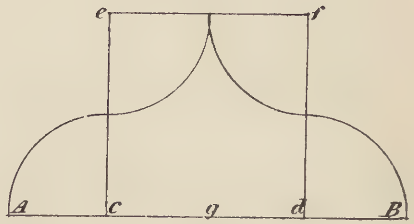


Fig. 3.

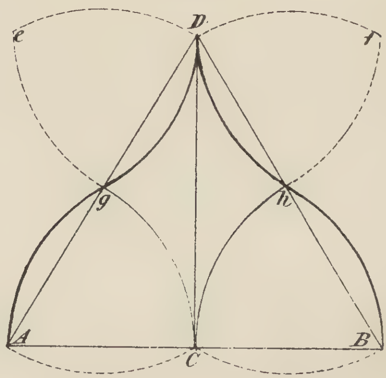
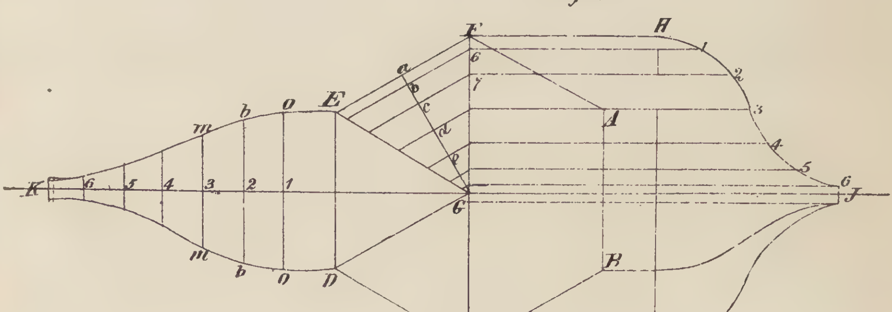


Fig 4.



To draw an Ogee Arch.

Fig. 2.—Divide the width AB into four equal parts, A *c g d* B, and on *c d* erect the square *c e d f*: the points *c d e f* are the centres of the four quadrants composing the arch.

Another Method.

Fig. 3.—Let AB be the width and CD the height of the arch, join ADBD and bisect them in *g* and *h*; then from the centres A *g* D *h* B describe arcs intersecting at *e f* C, which are the centres of the four arcs composing the arch.

To find the covering of an Ogee Dome, the plan of which is Hexagonal.

Fig. 4.—Let ABCDEF be the plan, and H IJ the elevation. Divide HJ into any number of equal parts, as 1 2 3 4 5 6, and through these points draw perpendiculars to FG; through the points in FG draw lines parallel to FE (the side of the hexagon) to EG, bisect EF in *a*, and draw *a* G, which is the seat of one side of the dome. Now to find the development of one section, set off the lines 1 2 3 4 5 6 K the same distance apart as 1 2 3 4 5 6 on the elevation from H to J. Then take

a E or *a* F on the plan, and transfer it to 1 *o* each side of 1 on the pattern; now take *b* 6 on the plan, and transfer it from 2 to *b* on each side; then *c* 7 on the plan transfer to 3 *m*, and so on to K, and through the points *o b m*, etc., trace the curve as shown, and it will form the covering for one side of the dome. All the sides being equal, of course, the pattern of one side is all that is required.

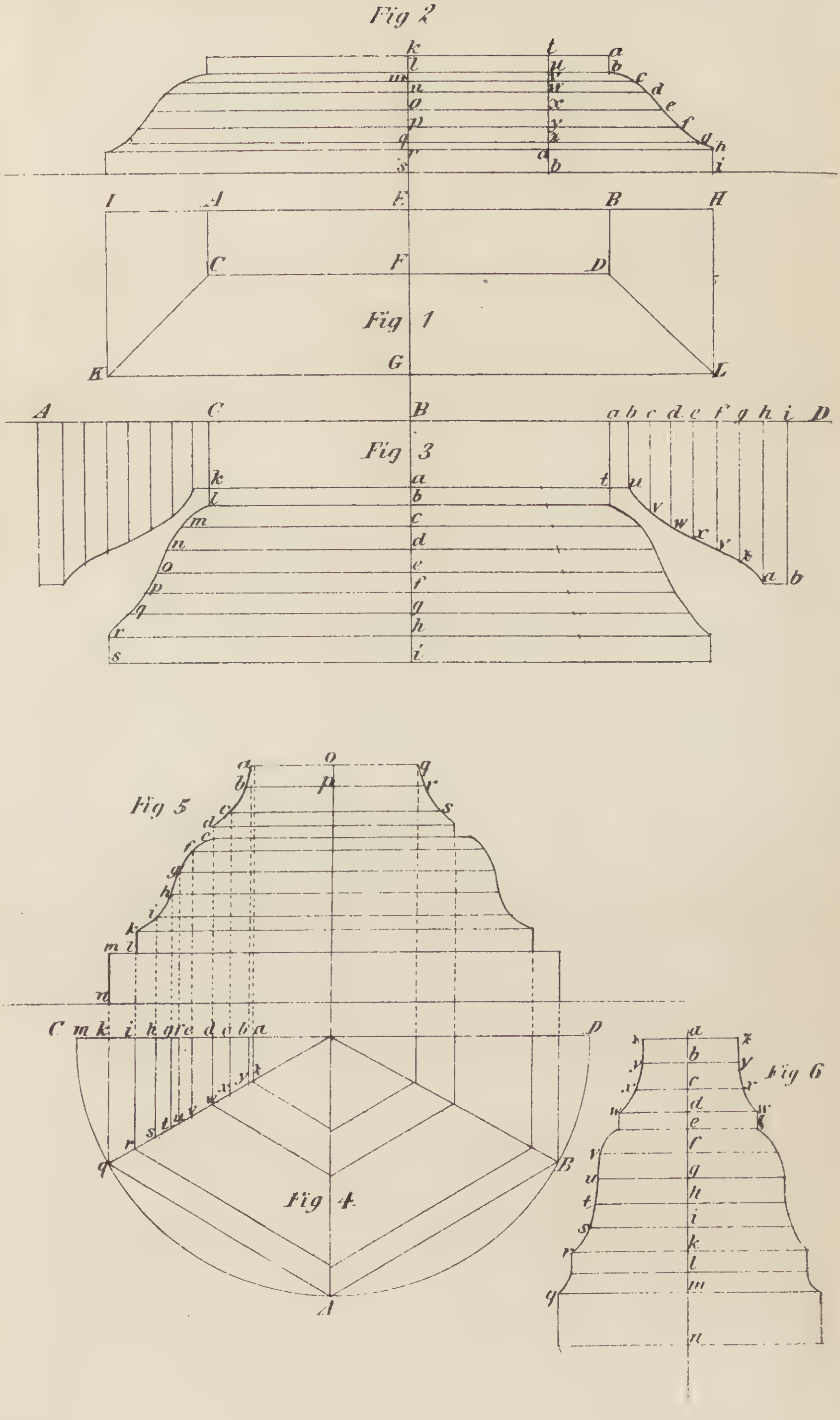
PLATE XXII.

To describe the pattern for a Rectangular Base and Bottom in one piece, where the flue or curve is equal on all sides.

Such as may be used as a base for either an Aquarium or a Fern-case.

Draw fig. 1, which represents half the projection; fig. 2 shows the elevation and profile of the base. Next, in fig. 3, draw the rectangle C *k t a*, same size as ACDB in fig. 1. Take the upright distance from *a* to *b*, and divide the curve into any number of equal parts, as *c d e f*, etc., and mark off corresponding distances on the perpendicular line from *a* to *i*, also from *a* to *i* on the line BD, likewise from C to A, and draw parallel lines from these

Plate 22



points, and the distances from *k* to *a*, *m* to *c*, and *n* to *d* etc., will show the required distances, as from *b* to *l*, *c* to *m*, and *d* to *n*, to be taken on each side of the centre line, fig. 3. Then by taking the distance from B to D in fig. 1, and marking off the same from *a* to *t*, fig. 2, and drawing the perpendicular *t b*, the required length of the lines will be obtained, as from *b* to *u*, *c v*, *d w*, *e x*, etc., in fig 3. A curve drawn from the points thus obtained will give one half the required pattern.

To describe the pattern for a Hexagon Base.

Draw fig. 4, the half hexagon so placed that half of a side, as *q k*, will be perpendicular and at right angles with the base. Draw a perpendicular line, *o* A, and lines from B and *q* to the centre. Now in fig. 5 (the elevation) divide the curve into a convenient number of parts, and draw the horizontal lines, and also the perpendiculars, and extend them to cut the line drawn from *q*, to the centre at *q r s t*, &c. Now draw the perpendicular *a n* in fig. 6, and carry on this line all the distances of the straight lines and angles, likewise the points of division on the curve of the elevation (fig. 5), as *n m l k i*, &c., to the points marked by corresponding letters in fig. 6, and

through the points thus received draw parallel lines at right angles with the perpendicular *a n*, and on each side mark off the points *a z*, *b y*, *c x*, and *d w*, the same distance as the corresponding letters in fig. 4. By connecting these points by curves and right lines (according to the plan in fig. 5) the required pattern will be obtained.

PLATE XXIII.

To describe the pattern for a Vase, Octagon Shape.

Draw the profile (fig. 1) the required design, and the half octagon (fig. 2) the size corresponding with the extreme points in fig. 1 (as described in fig. 4, Plate 3) and to be placed so that one half of the side, as from A to E, may be perpendicular with the base, and draw section lines from points A, B, C, and D, to the centre G, now divide the curve in the plan into any convenient number of parts, as *a b c d*, &c., and from these points draw horizontal lines across the plan, also draw perpendiculars and extend them to cut the line AG. Now mark off the same distances as shown by corresponding letters in fig. 3, and from these

Plate 23

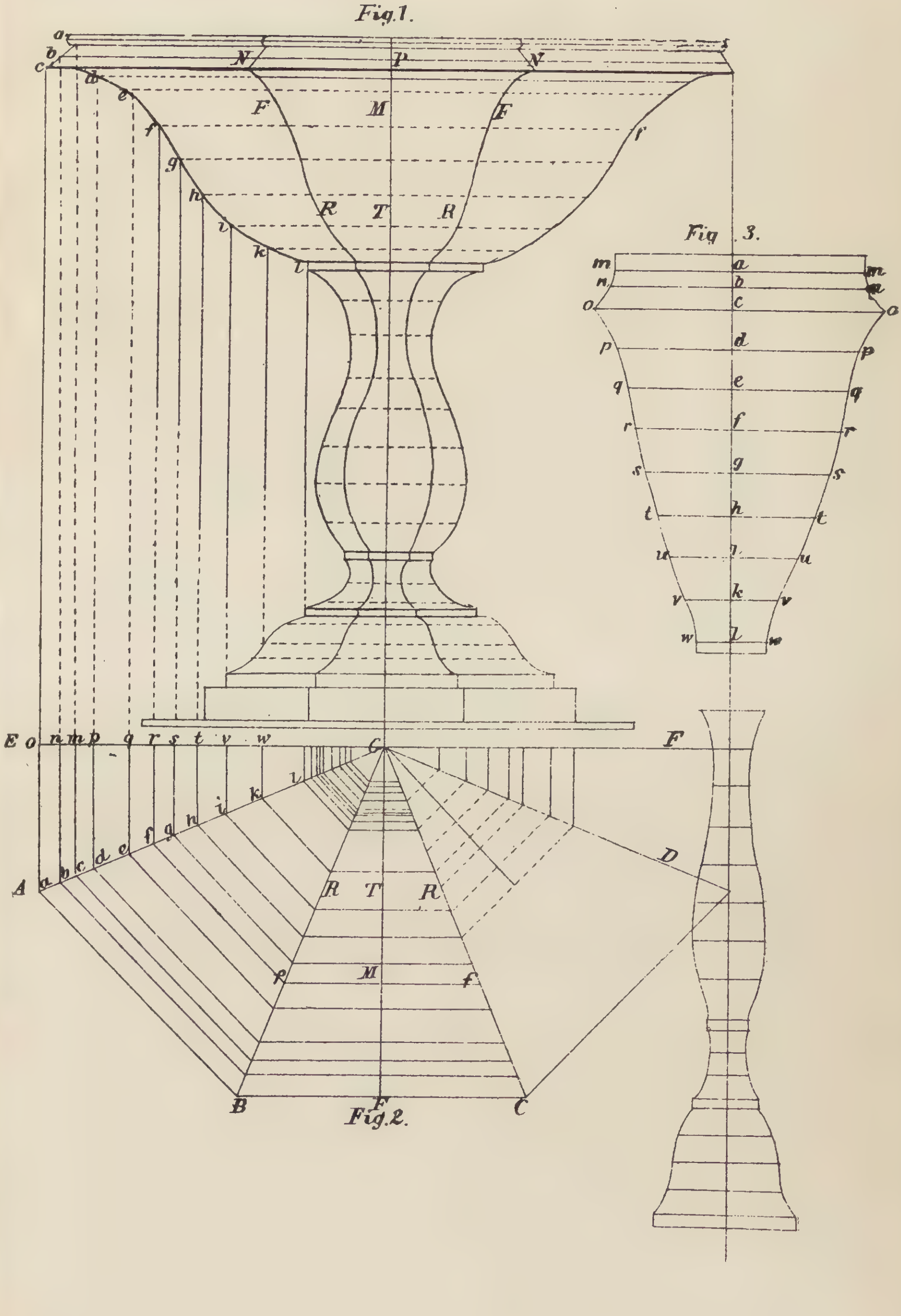


Fig.1.
Fig 3.
Fig.2.
E o n m p q r s t v w G F
A a b c d e f g h i k l
B F C D
N P N
F M F
R T R

points draw parallel lines *m m*, *n n*, *o o*, etc., take the length of the line (produced from *a*) from *c* to *m* (fig. 2) and mark off the same from *a* to *m* on each side of the perpendicular line in fig. 3, also the distance from *b* to *n* (being the line produced from *b*, fig. 1), and mark off the same from *b* to *n* (fig. 3), also let the distance from A to *o* (fig. 2) be carried from *c* to *o* (fig. 3). Now take the distance from *d* to *p* (fig. 2) and carry the same from *d* to *p* (fig. 3), and so on; tracing all the distances between the lines EG and AG, until all the points in the development of the pattern are obtained, and draw a curve from these points, which will complete the pattern.

To make the pattern look more complete, and to give a prospective view of the article, the course of the curves N, F, R, may be obtained in the following manner (although not necessary for the development of the pattern): From the points *a b c d e f*, etc., on the line A G (fig. 2) draw lines parallel to AB, to cut the section line BG, and again produce them to cut the line CG parallel with BC. Now if a vertical line was raised from B and C in the projection (fig. 2) it would cut the horizontal line *c* in the elevation at N and N; also by following the line from *f* in the elevation to *f* M *f* in the projection, and raising perpendicu-

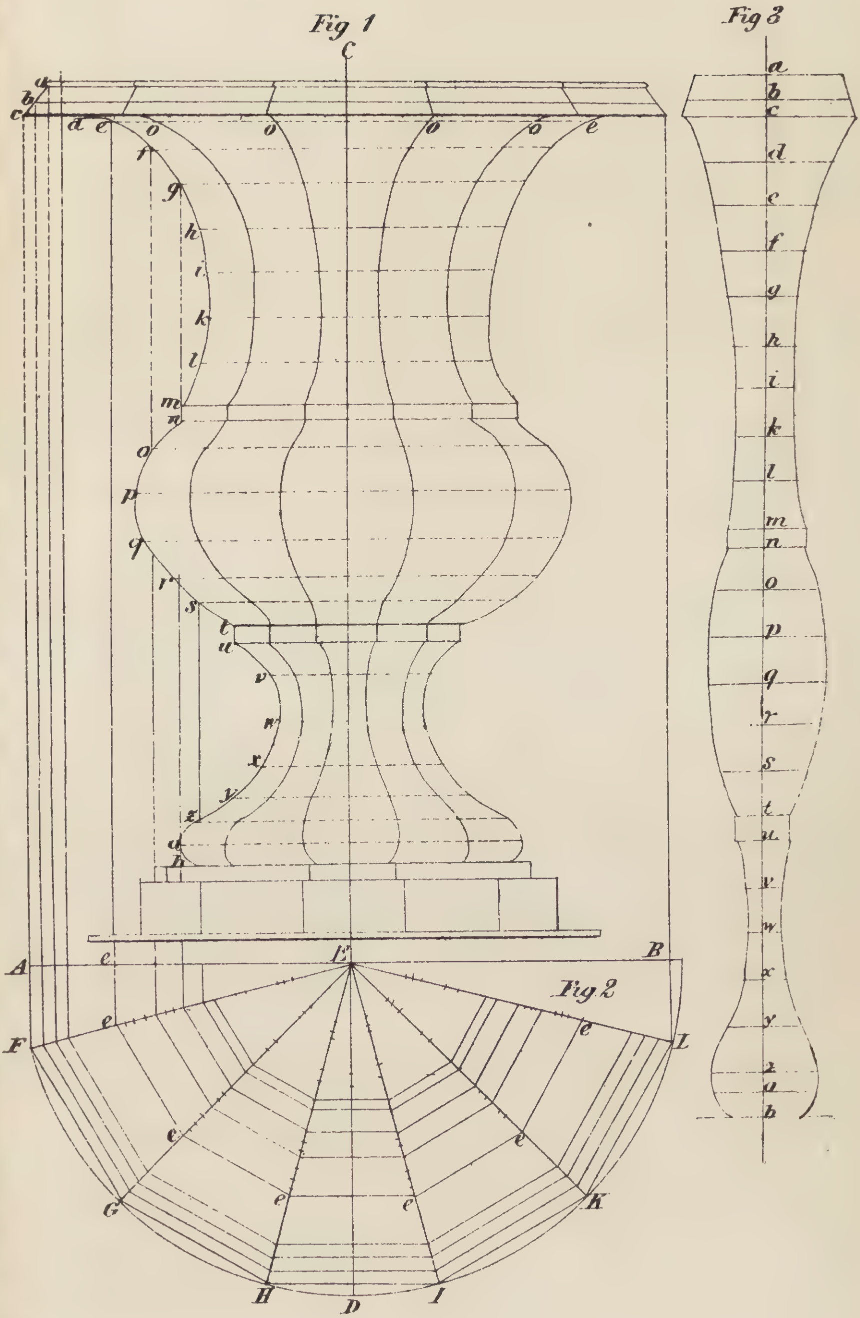
lars as before, they will give the points FF in the elevation; likewise by following the perpendicular from *i*, produced at RR in fig. 2, perpendiculars raised from these points will give the points RR in fig. 1. By tracing all the points in like manner the course of the curves NFR, etc., will be found. And it will be observed that these curves will show the same width as the pattern (fig. 3) all the way through, while the length of the pattern will correspond with the length of the curve of the side, as at *a b c d e f*, etc.

PLATE XXIV.

To describe the pattern for a Vase having twelve sides (Duodecagon).

Draw the profile fig. 1 (the two outer curves only), also draw the perpendicular line CD through the centre, and draw the horizontal line AB (fig. 2), on which construct half the plan of the projection as in Plate XXIII., and draw the sectional lines from points FGHIK and L, to the centre E, having half of a side from F to A perpendicular, and at right angles with the base. Now divide the outer curve in

Plate 24.



the plan into any convenient number of parts, as *a*, *b*, *c*, *d*, *e*, *f*, &c., and from these points draw horizontal lines across the plan, also draw perpendiculars, and extend them to cut the line F E, observing the points from which they are produced, take the distances between the lines AE and FE, and transfer them to the lines marked by corresponding letters in fig. 3. Now connect the points FG, GH, and HI, etc. (fig. 2), and draw lines parallel from all the points produced on the line FE; observing that where there are straight parts in the elevation, as from *m* to *n*, and from *t* to *u*, the same distance be taken, as marked by the corresponding letters in the development of the pattern (fig. 3), and the two lines as *t* and *u* will be connected by lines at right angles (as they are both the same length).

Now carry parallel lines from all the points on the line FE to all the other sectional lines in the projection, as from F to G, G to H, and H to I, etc., and by raising perpendiculars from these points, or by marking off points perpendicular to them on the corresponding horizontal lines in fig. 1, the course of all the curves may be obtained, showing all the joints and angles, or giving a prospective view of the Vase. For example, by following the perpendicular line drawn from *e* (fig. 1), to *e* on

the line FE (fig. 2), and all the other sectional lines marked by *e*, perpendiculars raised from these points, on the lines GHI and K, will give the direction of the various curves on the horizontal line *e e* (fig. 1), as *o o o o*.

PLATE XXV.

To describe the pattern for a Cone with an Elliptic Base.

In fig. 1, let AB represent the major diameter, and DD the minor, and E (the centre of the base) to F (the apex) represent the vertical height. Now draw half of the ellipse, as from A to B, and divide it into a convenient number of equal parts, as 1, 2, 3, 4, 5, 6; and from these points, using E as centre, describe arcs to cut the base line AB. Now taking F for centre, radius FB, draw the curve BA in fig. 2, and so from all the points from B to D, describe the curves in fig. 2 to A. With the same compass set as the divisions 1 2 3 4 5 6 in fig. 1 were obtained by, take twice that number in fig. 2, but in measuring off the distances with the compasses in fig. 2, commencing on the outer curve, from each point step

Plate 25

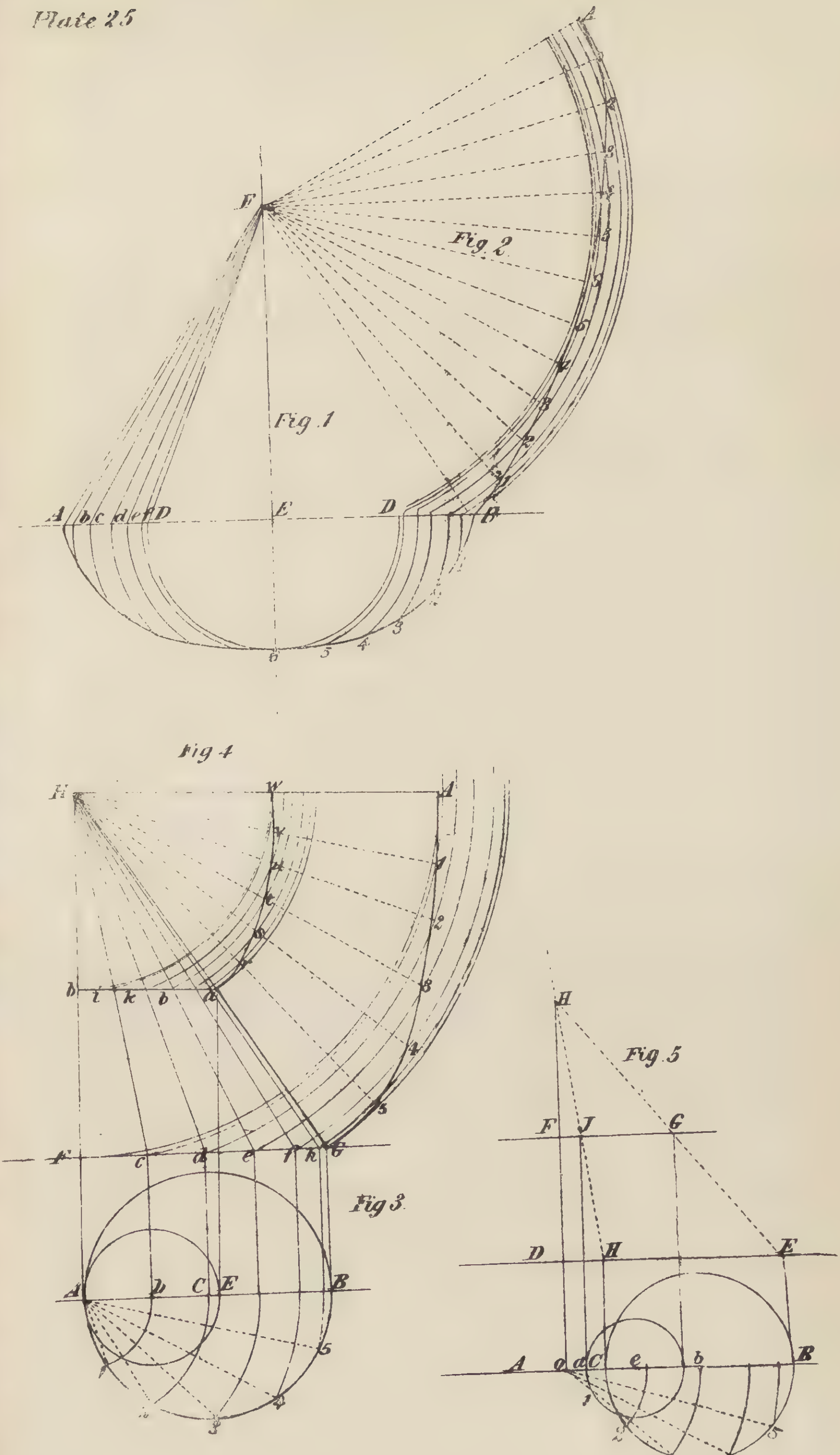


Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
A b c d e f D
E
D
B
F
A
B
C
E
b
H
F J G
D H E
A o d C e b B

into the next one, as 1 2 3 4 5 6, and then retreating back in like manner to A; lines drawn from those points to the centre F, and a curve drawn from the points so obtained, will complete the pattern; the length of the lines drawn from FA, F1, F2, F3, &c. (fig 2) will be equal to the length FA, F *b*, F *c*, F *d*, &c. (fig. 1).

To describe the pattern of an Oblique Cone, or the Frustum of a Cone cut parallel with the Base.

The vertical position of the two diameters is shown by the two circles in fig. 3. Now take the upright height from F to *b*, and draw FG and *b a* parallel to AB, the diameter line (being drawn across the two centres by which the circles are struck), and draw AH perpendicular to AB; also draw perpendiculars from E to *a* and from B to G, and draw a line from points G and *a* to cut the line AH. Now FH represents the vertical height of the cone, and FG the base, and the line *b a* shows the frustum or section required, the apex or point being cut off parallel with the base.

Divide half the plan into equal parts, as 1, 2, 3, 4, 5, and draw lines from these points to A. Now using A as centre, draw arcs from these points, as 1 D, 2 C, etc., to cut the dia-

meter AB, and draw perpendiculars from these points to the base line FG. Next using the point H as centre (fig. 4), describe arcs from G *h f e d c* and F to A, also from *b i k*, etc. Now with the same compass set as the plan is divided by, as 1 2 3 4 5 B, mark off the same distances in fig. 4 from G to 5 4 3 2 1 and A, stepping from the outer curve into the second and third, and so on, and draw lines from these points to the centre H. By drawing curves from these points of intersection as A 1 2 3 4 5 G, and also from *w v u t s r* and *a*, one half of the development will be obtained.

Fig. 5 is a further illustration of the same principle. The two circles struck from centres on the line AB, show the vertical position of the section of the cone required, and from D to F the elevation. Draw perpendicular lines from C to H and from B to E, being the diameter of the base, also carry perpendiculars showing the diameter of the top of the cone to J and G, join HJ and EG, and produce them to meet at the point H, and draw a perpendicular line from H to cut the line AB at *o*, which will be used as a working centre, as the point A is in fig. 3; likewise the development will be obtained in the same manner.

Plate 26.

Fig 1.

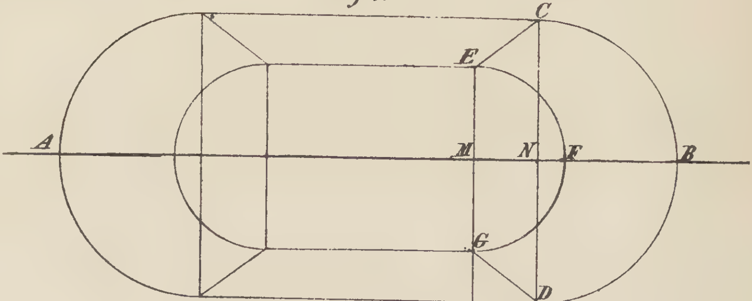


Fig 2.

Fig 3.

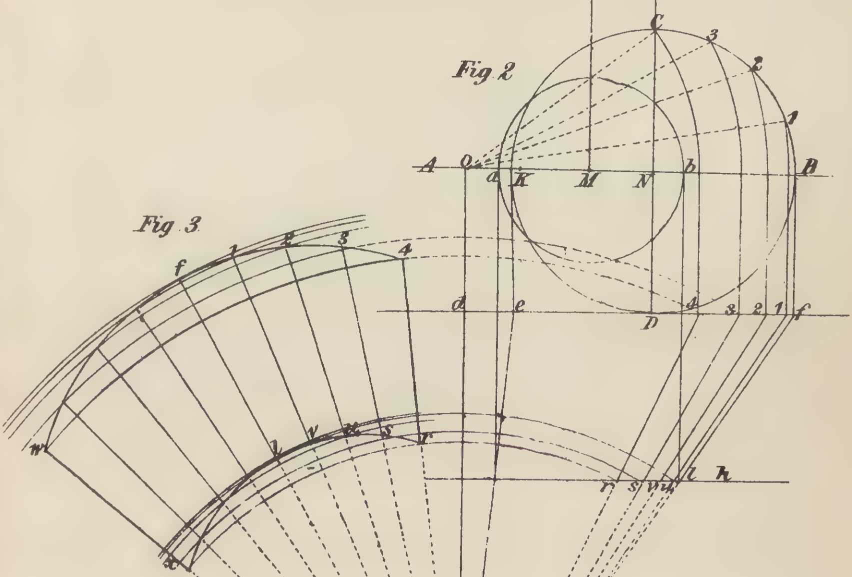


PLATE XXVI.

To describe the pattern for a Round-end Bath, tapering more at the ends than at the sides.

It will readily be seen that the pattern required for the end of this bath is a section of the oblique cone in the last plate. The semicircles CBD and EFG being struck from N and M as centres, extend these lines to N and M on the line AB (fig. 2), and draw two circles corresponding with the semicircles in fig. 1; one quarter of the circumference is all that is required to be divided here, as from B to C; the lines *d f* and *g h* being drawn the same distance apart as from *t* to *u*, the upright height. The vertical line from *m* to *o* will be obtained as explained in Plate 25, figs. 4 and 5. It will be observed that lines drawn from 1 2 3 and C to *o*, the working centre, will also divide the same section of the smaller circle into a like number of equal parts (a line drawn from C to *o* being perpendicular with the centre N, also cuts the perpendicular from M, the centre of the smaller circle). Now using *o* as centre describe the arcs from C 3 2 1 to cut the diameter AB, and draw the perpendicu-

lars to meet the line $d f$, as at 4 3 2 1 f; from the points thus obtained strike the various curves in fig. 3, as previously explained in Plate 25, figs. 2 and 4; and from the point m draw line $l f$, and with the same compass set as the section BC (fig. 2) is divided by, mark off the same distances from f to 1 2 3 4 (fig. 3) from the outer to the inner curve, also from f to w. Now draw lines from these points to the centre m, and draw a curve from the points of intersection, as from 4 3 2 1 f, etc., also from the points $r s u v$, etc., which will give the development of the pattern for the end, so far as shown by the semicircles in the plan CBD and EFG.

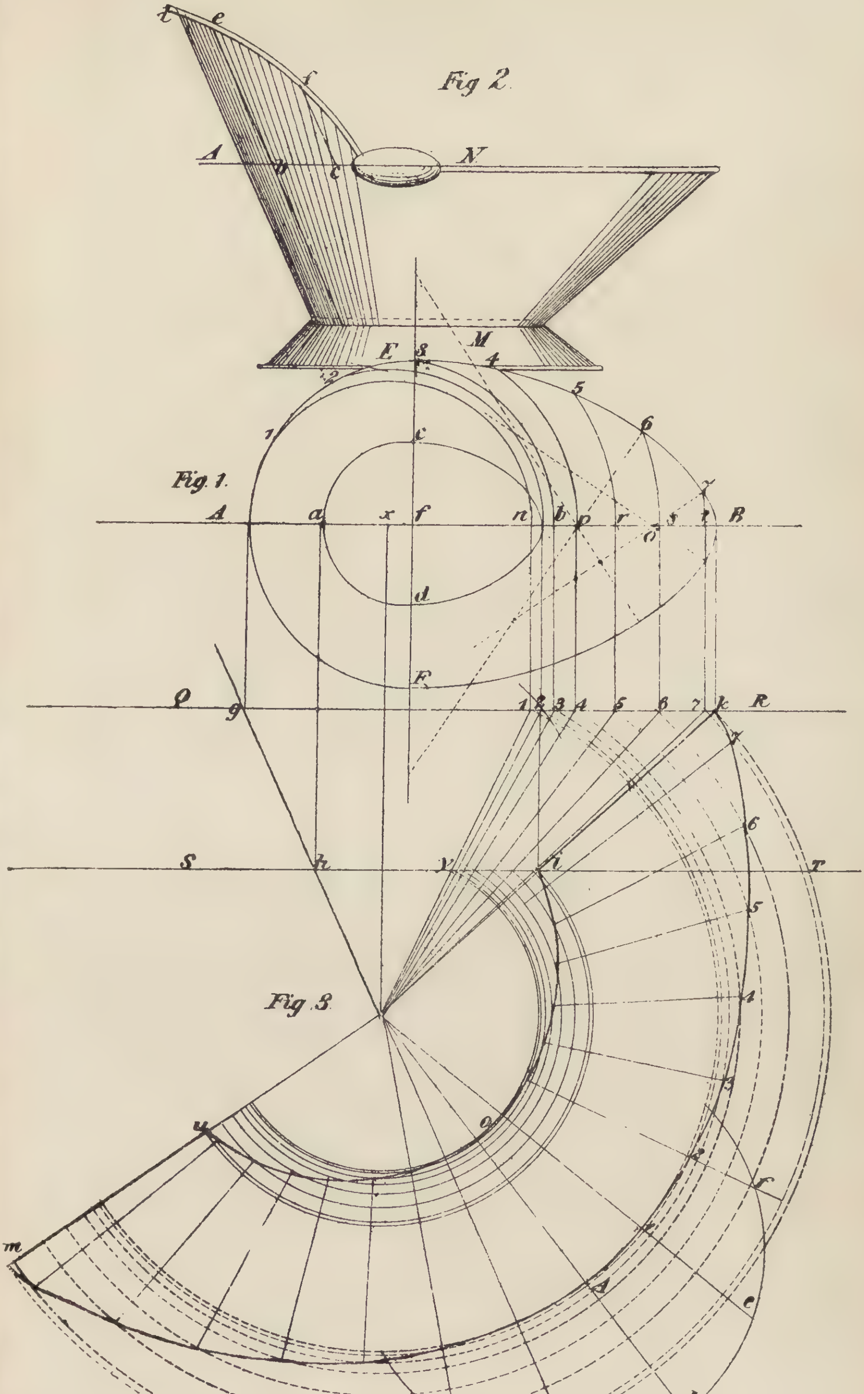
PLATE XXVII.

To describe the pattern for a Hip Bath.

Fig. 1 shows the plan, also the position of the bottom, which may be drawn to any given dimensions. Let the lines QR and ST represent the perpendicular height, as from M to N (fig. 2), both drawn parallel to the diameter line AB (fig. 1).

Draw perpendicular lines from the extreme

Plate 27



points B and A in the plan to *k* and *g* on the line QR, which will represent the top of the Bath; also perpendiculars from *a* to *h*, and from *n* to *i*, on the line ST, showing the position and length of the bottom. The smaller oval need not necessarily be drawn, only the points *a* and *n* marked off, showing the position of the bottom or the required slant of the toe and back, as the shape of the bottom will be found in the development to come in proportion.

Draw lines from the points *g h* and *k i*, and produce them to meet at *w* (fig. 3); now from *w* draw a perpendicular line to cut the diameter AB at *x* in the plan, which is to be used as a working centre; next let one-half the plan from A to B be divided into any number of parts, as 1, 2, 3, 4, 5, 6, 7, and from these points, using *x* as centre, describe arcs cutting the diameter line AB, as at *t s r*, etc., and draw perpendiculars to cut the line QR, as marked by figures corresponding with those on the curve. Now, by using *w* as centre, and describing the various portions of circles, as shown, from 1, 2, 3, 4, 5, 6, 7 and *k*, likewise from the points from *y* to *i*, and taking the same distances from *k* to A and from A to *m* (on the arcs *k*, 7, 6, 5, etc.) as the divisions in the plan from B to A (in fig. 1); and by drawing

lines from 7, 6, 5, 4, etc., leading towards the centre *w*, all the points of intersection will be obtained, from which the curves may be drawn (by free hand) to give the development of the pattern in one piece.

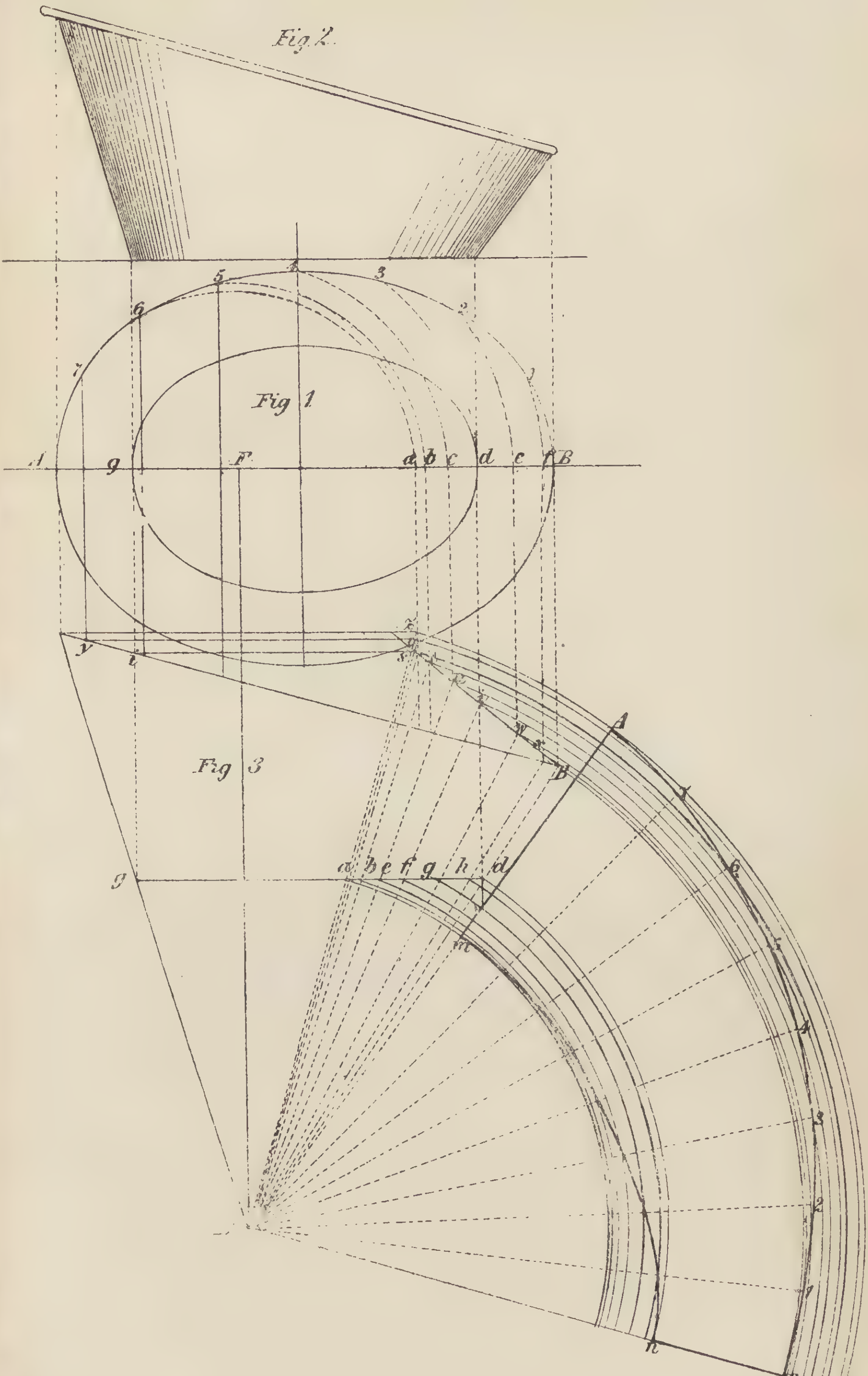
To obtain the shape of the back, draw the curve *d e f*, in fig. 2, as required, and mark off points *b* and *c*, perpendicular to 1 and 2 in fig. 1, and draw *b e* and *c f* parallel with A *d*; now transfer the lengths of A *d*, *b e*, and *c f*, from A to *d*, 1 to *e*, and 2 to *f*, in fig. 3, which will give the course of the curve of the back to correspond with the plan of the same in fig. 2.

PLATE XXVIII.

To describe the Pattern for a Travelling Sitz Bath.

Fig. 1 represents the plan of the top and bottom required, and fig. 2 the elevation. (It will be seen that the tapering is as much in the front as at the back, but the back being much higher than the front, the tapering is not equal in proportion to the depth; this, however, may be governed according to dimensions required.) Let the horizontal line *g d*

Plate 28



(fig. 3) be drawn to represent the required length of the bottom, as shown by the dotted lines brought down from the plan (fig. 2), and let the line AB represent the slanting length of the top, as shown by its meeting the perpendiculars drawn from the top of the plan (fig. 2); now draw lines A *g* and B *d*, and produce them to meet at the apex E, and draw a vertical line from E to cut the line AB (fig. 1) at F, which will be used as a working centre.

Let one-half the ellipse be divided into any number of parts, as 1, 2, 3, 4, 5, 6, 7, A, and using F as centre, describe the arcs cutting the diameter line AB, as at *f*, *e*, *d*, *c*, *b*, *a*; and from these points draw perpendiculars, as shown by the dotted lines. It will now be observed that the radius from F to A and from F to 7 will be (in this case) the same as from F to 6, by which the arc from 6 to *a* is drawn, which will prevent separate arcs being described from points 7 and A, as shown from all the other points; therefore a perpendicular from point 6 must be drawn to cut the line AB (fig. 3) as at *i*, and from this point draw a line to *s*, parallel with *g d* (to cut the perpendicular from *a*), and from point *s* draw a line to B, which will give the various heights (where intersected by the perpendiculars drawn from *b*

cdef) of the Bath from B to the point 6 (fig. 1). Now, from point 7, draw a perpendicular to cut the line AB (fig. 3) at *y*, and a perpendicular from A (fig. 1) to A (fig. 3); now, from *y* and A draw lines parallel to *g d*, to cut the perpendicular dotted line from *a* (fig. 1), as at *o* and *z*, which will give the two remaining points which were deficient while in the process of describing the arcs; and from all the points, as *z*, *o*, *s*, *t*, *u*, *v*, *w*, etc., describe arcs indefinitely; now draw lines from all these points to the apex E, and where the line *g d* is cut, as at *d*, *h*, *g*, *f*, etc., will be the points from which another set of arcs are required to be drawn. Take the same compass set as half of the plan (fig. 1) is divided by, and measure off the same number of distances from B 1 2 3, etc., in the development (fig. 3), stepping from the first arc into the second, third, and so on; and draw lines from all those points to the apex E, which will give the points of intersection on the smaller set of arcs. Now by drawing the curves from these points of intersection from *m* to *n*, and from the points A to 7 6 5, etc., to B, will give one-half of the pattern required.

PLATE XXIX.

To describe the pattern for a Globe, formed of twelve pieces joined together.

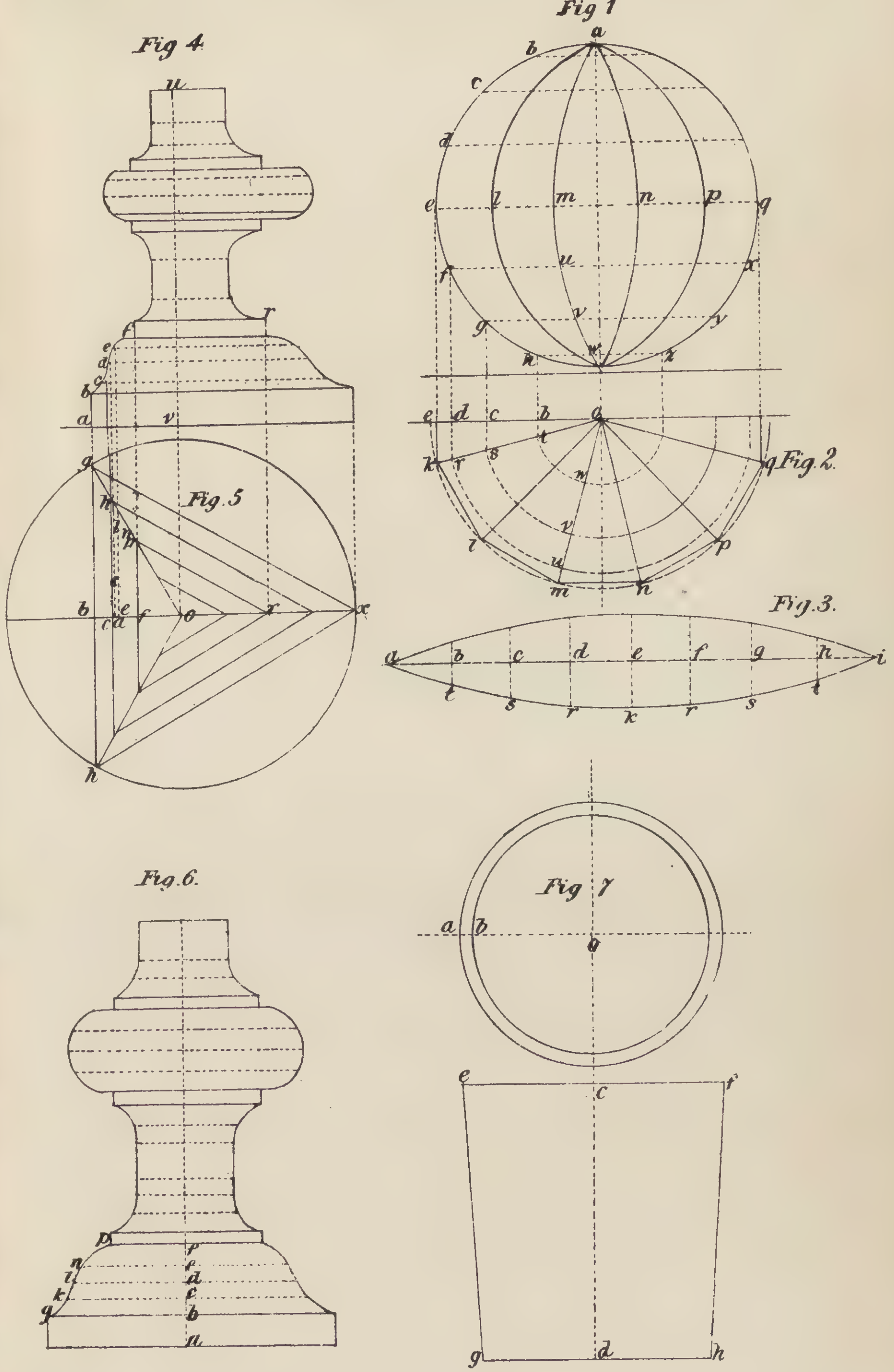
In fig. 1 describe a circle the required size, and draw the perpendicular *a w*; now divide the half circle into any number of parts, as *a b c d*, etc., and draw the horizontals, as *e q*, *f x*, *g y*, etc.; next draw in fig. 2 half a circle, and divide it into six equal parts, having half a side from *e* to *k* perpendicular with the base; now in fig. 3 draw line *a i*, and mark off the points *a b c d e*, etc. the same distance apart as the corresponding letters in fig. 1, also draw perpendiculars in fig. 1, from points *h g f e*, etc. to cut the line *k o* (fig. 2), and let the distances from *b* to *t*, *c* to *s*, *d* to *r*, and so on, be transferred to corresponding points in fig. 3, which will give the course of the curve to complete the pattern.

To describe the pattern for a Triangular Pedestal or Pyramid, with all three sides alike (an equilateral triangle).

To draw the projection for this figure, let the point *x*, and the centre point *o*, come in a

horizontal line, also at right angles with the line *u o*, which represents the real centre of the article, not the centre of either of the sides. Now in order that the curves may be equal on all sides, divide the circle into three equal parts, from *x* to *g* and *h*, and draw lines to the centre *o*. Now draw the required shape for the side in fig. 4, from *a b c d e f*, etc., and let this side be divided into any number of parts, and draw horizontal lines across the profile, likewise perpendiculars to intersect the lines *g o* and *h o* in fig. 5, and from these points draw lines parallel to *h x* and *g x*. Now by raising perpendiculars from all the points on the line *o x*, as shown from *x* and *r*, the direction of the curve will be obtained, showing the point or angle of the article, which at first may appear to have more curve, but by referring to the plan (fig. 5) it will be seen that the one gives a view of the side, and the other that of a point or angle. Now to develop the pattern (fig. 6) will require but little further explanation; the distances between the lines *a b c d*, etc., are transferred from the corresponding letters in fig. 4, and the lengths from *b* to *g*, *c* to *k*, etc. are equal to those similarly marked in fig. 5, which will give the course of the curves to complete the pattern.

Plate 29.



To obtain the radius required for striking the pattern of a slightly Tapering article, without the necessity of producing lines to meet.

Let the two circles in fig. 7 represent the diameters at the top and bottom, as *e f* and *g h*, then the distance from *a* to *b* will show the flue on all sides. Take the distance from *a* to *b* with the compasses, and measure off or find how many times that distance there is between *a* and the centre *o* on the diameter line: in this case 9. Now let the upright depth, as from *c* to *d*, be multiplied by 9, and the result will be the radius required, or the length of string or wire to strike the curve with.

To show an example. Suppose the diameter of the larger circle is 18 inches, and that of the smaller one 16 inches, the distance from *a* to *b* would be 1 inch, and from *a* to *o* would be 9 times as much as from *a* to *b*. Now suppose the upright depth from *d* to *c* be 2 feet. Therefore, 9 times 2 being 18, a radius of 18 feet would strike the required curve for the pattern.

PLATE XXX.

To describe the patterns for the sides of an Irregular Octagon Pan.

Figs. 1 and 2 show the plan and elevation of the article required, having the flue or curve equal on all sides, as shown by the distance from *c* to *l* and from *y* to *x*, these being alike; therefore all that is needed to be described is to divide the curve (fig. 1) into equal parts, as *a*, 1, 2, 3, *b*, and take the same from *a*, 1, 2, 3, *b* on the perpendicular lines in figs. 3, 4, and 5; and the widths of these patterns will be obtained from the plan (fig. 2), as previously described in Plates XXII. and XXIII.

Figs. 6 and 7 show also the plan and elevation of an irregular octagon article, where the curve will not be alike on all sides, but proportionate, and its angles or section lines all leading to the centre.

Draw the elevation (fig. 6); also draw half the projection (fig. 7) AGFEDC, as required, and draw the sectional lines, from G, F, and E, D, to the centre B. Divide the curve from *c* to *f* into equal parts, as 1, 2, 3, 4, 5, and draw horizontal lines across the plan from

Plate 30

Fig 1

Fig. 2

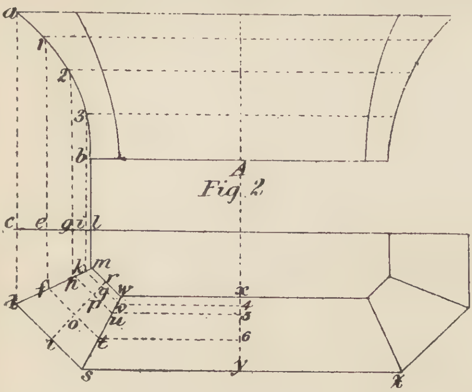


Fig 3

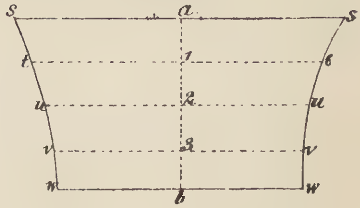


Fig 4

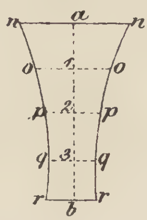


Fig. 5

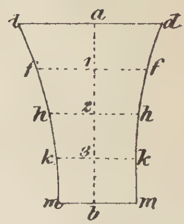


Fig 6.

Fig 7.

Fig 8.

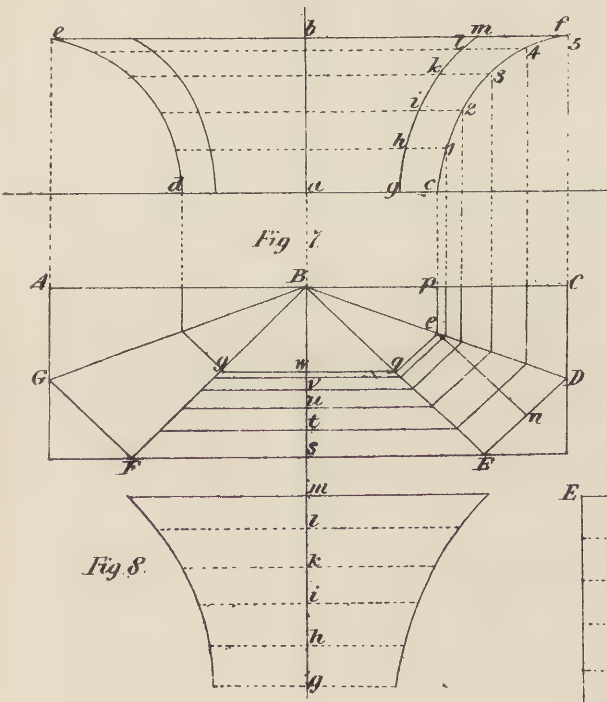


Fig 10

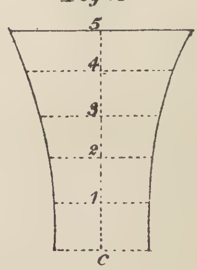
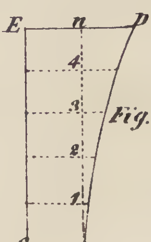


Fig. 9.



these points; also perpendiculars to cut the line DB, and carry the lines from D *e* to E *g* and F *g* parallel with DE and EF.

Now to obtain the pattern for the end, draw the perpendicular (fig. 10), and mark off the same distances as 1, 2, 3, 4, 5 (fig. 6), and take the distances from CD to *p e* on each side, which will give the widths of the pattern.

Next draw the line *e n* (fig. 7) at right angles with *g e*; and as this line *e n* is the same length as from *p* to C, draw the perpendicular *c n* (fig. 9), and draw the parallel lines 1, 2, 3, 4, *n*, the same distance apart as in fig. 10. Now mark off the distance from *n* to E and D, the same as from *n* to E and D (fig. 7); likewise transfer all the distances on each side of the line *n e* in the same order on fig. 9, as shown; and lines drawn from the points thus obtained will give the pattern for the small side.

Now the projection of the side from *w* to *s* being much less than that of the end from *p* to C, proceed as follows:—take the distances (fig. 7) from B, the centre, to *w*, *v*, *u*, *t*, and *s*, and mark off the same (fig. 6) from the perpendicular *a b*, to *g*, *h*, *i*, *k*, *l*, and *m*, and draw a curve from these points, which shows the fall of the side before mentioned; now draw the perpendicular (fig. 8), and draw the

parallel lines *g*, *h*, *i*, *k*, *l*, *m*, the same distance apart as the corresponding letters in the elevation (these will not be equal distances apart, as in figs. 9 and 10), and make them the same length as the lines *s*, *t*, *u*, *v*, *w* (fig. 7); this being done, will give the course of the curve required to complete the pattern.

[The few points of variation between this and the plates heretofore referred to are recommended to be well studied; they will be found of great assistance in studying Plate XXXI.]

PLATE XXXI.

To describe the pattern for a Cover and Neck of an Irregular Octagon Article, such as a Tureen.

Fig. 1 represents the elevation and the required curves, and fig. 2 shows one half the plan.

To obtain the pattern for the cover, first draw the half octagon *z x u b i v n* (fig. 3) the same size as *z x a b i d n* (fig. 2), and draw through the centre the perpendicular line *b h*.

Draw the line from *x* to *f* at right angles to

Plate 31.

Fig 1.

Fig 2.

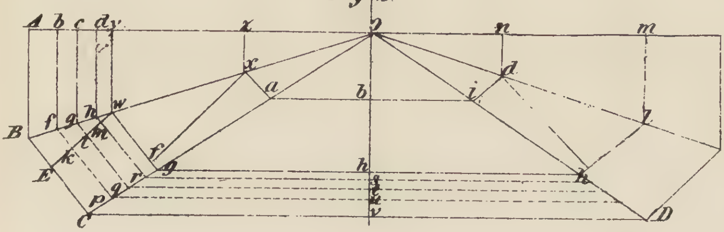


Fig 3

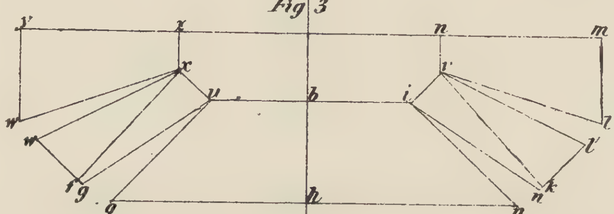


Fig 4

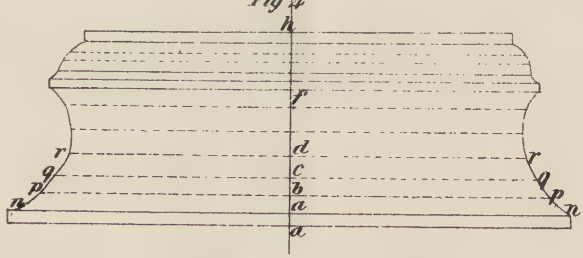


Fig 5

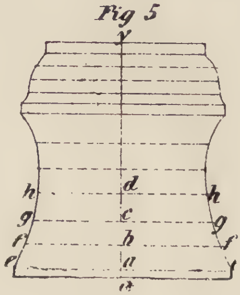
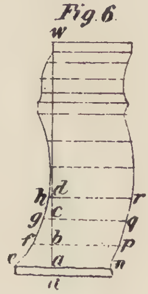


Fig.6.



x u; also from *v* draw the line *v k*, at right angles with *v i*; then take the length of the line *x w* (fig. 1), and carry the same from *z* to *y* and *n* to *m* (fig. 3), and draw the perpendiculars *y w* and *m l*; then take the length of *y w* (fig. 2), and mark off the same from *y* to *w* and *m* to *l* (fig. 3), and draw the lines *w x* and *l v*. Now, in the projection (fig. 2), draw a line *x f* from *x*, at right angles with *x a*, and carry the length of *x f* from *y* to *f* (fig. 1), and raise the perpendicular *y x*, and draw line from *x* to *f*. Now take the length of *x f*, and mark off the same from *x* to *f* and *v* to *k* (fig. 3), and draw the line *w g* through the point *f*, parallel to *x u*; take the distances from *f* to *g* and *f* to *w* (fig. 2), and mark off the same from *f* to *g* and *w* (fig. 3), and draw lines as *w x* and *g u*.

Now take the distances from *o* to *b* and *o* to *h*, in the projection, and mark off the same from *o* to *b* and *i* to *h*, in the elevation, and draw the line *b h*. Now take the length of *b h* (fig. 1), and mark off the same from *b* to *h* (fig. 3), and through the point *h* draw *g n* parallel to *u i*; take the length of *h g* (fig. 2) and mark off the same from *h* to *g* and *n* (fig. 3), and draw lines *g u* and *n i*, which completes half the pattern for the top.

Now to describe the patterns for the sides or neck. The octagon being irregular, and the

angles leading towards the centre, the several sides will take different curves ; therefore each section will have a little variation.

To obtain a pattern for the end of which B A represents one half, the process is simply to divide the curve from *a*, *b*, *c*, etc. to *g* and *w* (fig. 1), and draw the horizontal lines from these points, and also draw perpendiculars from the same points, and extend them to cut the lines AO and BO, in the projection (fig. 2). On the perpendicular line (fig. 5) take a corresponding number of distances, and draw the horizontal lines, as *a*, *b*, *c*, *d*, etc., and on each side of these points mark off the points *e e*, *f f*, *g g*, etc., the same length as AB, *b f*, *c g*, *d h*, etc. (fig. 2). A curve drawn from the points so obtained will give the pattern for the end.

Note.—The lines in fig. 2, as A B, *b f*, *c g*, etc., are not all that would be obtained from the points in the curve (fig. 1), but they will sufficiently illustrate the principle.

Now, to obtain the pattern for the side from B to C, draw the lines from *f* to *p*, from *g* to *q*, and from *h* to *r*, etc., parallel to BC, and draw a line from *w* to E, at right angles with *w f* or BC, precisely the same as the line *x f* was drawn at right angles with *x a*. Now draw the perpendicular line (fig. 6), also the

horizontals, as from *a* *b*, *c*, *d*, etc., the same distance apart as in fig. 5; and take the distances from E to B and C, and mark off the same from *a* to *e* and *n* (fig. 6), also the distances from *k* to *f* and *p*, and mark off from *b* to *f* and *p*, and so on until all the points are obtained, which will give the direction for the curve to be drawn to give the pattern for the small side.

Now draw lines from *p*, *q*, *r*, etc., parallel to CD (fig. 2), and take the distances from *o* *v*, *o* *u*, *o* *t*, *o* *s*, and *o* *h*, and transfer the same from *h* to *a*, *g* to *b*, *f* to *c*, and *e* to *d*, and so on, to *i* *h*; and from the points thus obtained draw the curve from *h* and *j* to *a*. Take the distances between the horizontals (previously drawn from the curve at the extreme end), and on the perpendicular (fig. 4) mark off corresponding distances, and draw the horizontal lines, and take the distances from *v* to C, *u* to *p*, *t* to *q*, and *s* to *r*, etc. (fig. 2), and transfer the same on each side of the perpendicular line (fig. 4), from *a* to *n*, *b* to *p*, *c* to *q*, etc. A curve drawn from these points will complete the necessary patterns.

PLATE XXXII.

To describe the pattern for the Top of a Jack Screen.

[It will be seen that in striking this pattern, sufficient allowance must be made for hollowing in addition to the leading points obtained. This must be left to the judgment of the workman, as there are no known rules to describe it.]

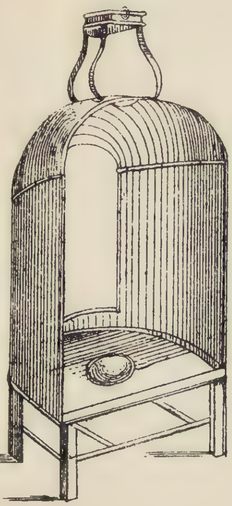
FIG. 5 represents the article of which the development of the top is required.

FIG. 1 shows the elevation or the shape of the front of the screen, and fig. 2 gives the shape of the top or projection, the top being intended to be made in three pieces.

Draw in the projection the shape of the hole for the jack to work through, as shown by *m q n*, and draw lines from *u* and *r* to the centre *p*, from any part of the outer curve that will make the back and side-pieces look proportionate or convenient for material. Now divide one side of the elevation into any number of equal parts, and draw perpendiculars to cut the line *w v* in the projection, as marked by corresponding figures; and from these

Plate. 32.

Fig. 5.



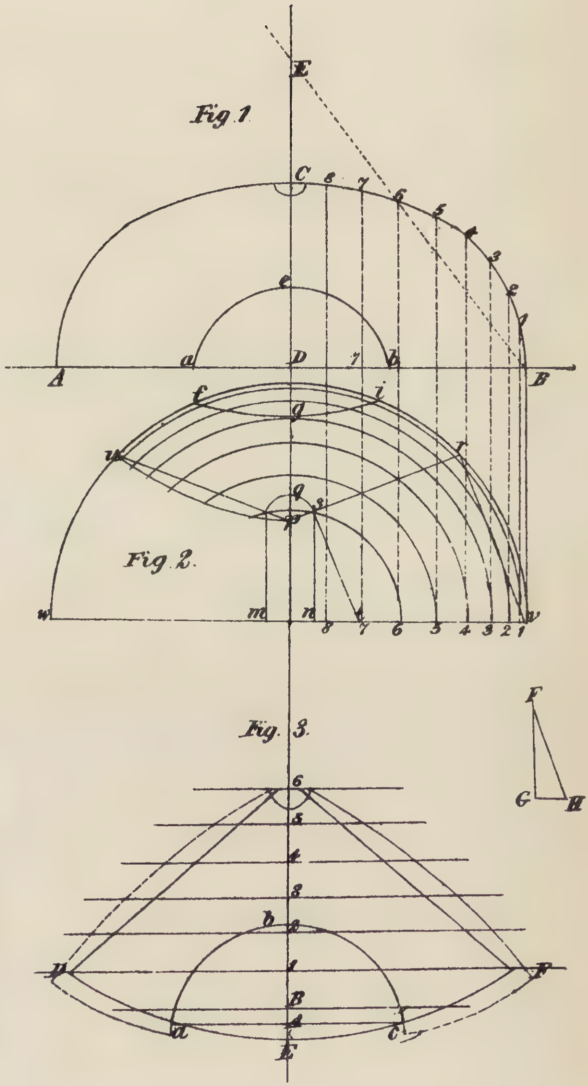
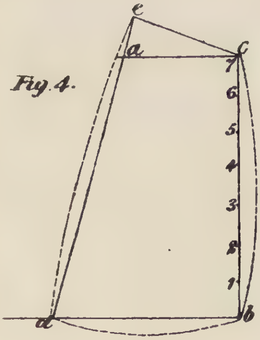


Fig. 4.



points describe arcs cutting the lines *r p* and *u p*.

Now the height of the top, as far as the back piece, will come, is shown by the arc drawn from 6 intersecting it at *s*; therefore, from B (fig. 3) mark off 1, 2, 3, 4, 5, 6, the same distance apart as the same figures in fig. 1, and draw the horizontal lines from B to 6. Now the curve *a e b* in fig. 1 represents the opening in the top for the doorway, and the curve *f g i* (fig. 2) gives its course in the projection, shown by the point *g* coming between the second and third arc, as the point *b* (fig. 1) comes between the second and third perpendicular; draw FGH at right angles, and take the distance from D to *e* (fig. 1), and mark off the same from G to F, also the distance from *g* to the outer curve in the projection, and mark off from G to H, drawing the line FH; now let difference between the distances from FG to FH to be added on from B to A (fig. 3), and draw the line *a c*; draw the curve *a b c* about one-fourth wider than *a b* in fig. 1, as it will draw in much closer by hollowing. Draw line from B to 6 (being the height of the back piece as previously stated) and extend it to cut the perpendicular at E; now with radius EB describe the curve for the bottom of the pattern from points *a* and c, and

take the distance from *f* to *u* (fig. 2) and an allowance for the seam, and mark off from *a* to D, and *c* to F, and draw lines from points so obtained to 6 ; now draw the dotted curves for the hollowing as shown according to judgment.

To obtain the pattern for the side draw the line *r v* at right angles with *r s*, and also the line *s t* in the same manner, now draw *c b a* (fig. 4) at right angles, and by taking the distance from *r* to *s* in fig. 2, and by measuring off the same distance on the line AB (fig. 1) from B it will just reach the perpendicular 7 ; now take the distance from B to 7 on the curve, and mark off the same from *b* to 7 on the perpendicular in fig. 4, and draw *c a* at right angles with *c b*. Take the distance from *s* to *t* (fig. 2) and mark off the same from *c* to *a* (fig. 4) also take the distance from *r* to *v* (fig. 2) and mark off the same from *b* to *a* (at the base, fig. 4) and draw line from points *a a* and extend it; now take the distance *n* to *t* (fig. 2) and let the same be added on from *a* to *e* (fig. 4) and draw line *c e*, this will give the main points and size required for the pattern of the side; curves for hollowing and wiring to be added on as shown by dotted lines.

SHEET-METAL WORK PROCESSES.

I.

SHEET-METAL WORKING.

The patterns and the manner of laying them out having been given in the foregoing pages, a cursory glance at the processes of sheet-metal work will now be taken.

When the form of the pattern has been marked out on the sheet metal, the next business is to cut it out: this is generally effected with a large pair of shears, either screwed up in the vice or with their shank dropped into a hole in the bench, and worked by hand (Fig. 1). In some instances, however, the cold chisel and hammer are employed, the work being either laid on the anvil direct or on a cutting-plate; in others, being screwed up in the jaws of the vice and cut off by the hammer and chisel, the latter being kept in contact with the upper surface of the vice-jaw as a guide. Sometimes, the thick

Fig. 1.

plates employed for boilers are screwed up in very long vices with a screw at each end and cut off by the chisel. There are also slitting-plates in large works.

The hammers (Fig. 2) are alike at both ends as a rule, sometimes with large faces either flat or convex. The faces or panes are always kept very bright, in order that they may impart some of their polish to the work, a process which is termed "planishing." Wooden hammers or mallets are often used to prevent stretching the sheet metal. The anvils are of very varied shapes, and generally placed in a hole in the work-bench. The smaller ones are usually called "stakes," and go down to half an inch square. Fig. 3 is the "hatchet-stake," and is much used for turning over edges, etc.; this varies from 2 inches to 10 inches wide. Fig. 4 is a "taper-stake," also much used. Fig. 5 is the "creasing tool," which is used for making small beads, tubes, etc. Fig. 6 is the "seam-set," used for closing the seams prepared at the hatchet stake. Fig. 7 is the "Holliper" or "Oliver:" it consists of two jointed arms, in which various kinds of top-

FIG. 2.

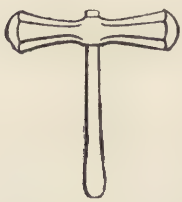
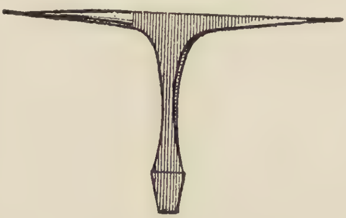


FIG. 3.

and-bottom tools, swages, etc., can be fixed, and the metal being placed between the dies, and the top forcibly struck with a hammer, the piece of tin, etc., is at once stamped out exactly to the contour of the dies.

Fig. 4.



The sides of the vessel (which is a shallow tray) represented in Fig. 8, if the metal be thin,

Fig. 5.

Fig. 6.

Fig. 7.

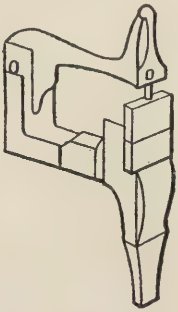
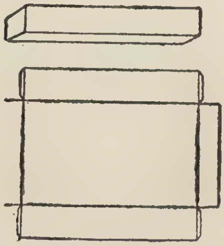


Fig. 8.



would be bent to the required angles by laying the metal horizontally on the hatchet-stake, with each angle line exactly over the edge of the same, and blows would be given with the mallet, or with the hammer for more accurate angles, so as to indent the metal with the edge

of the stake; it would then be bent down by the fingers, unless the edges were very narrow, as for the seam, when the mallet would alone be used. Thicker metal is more commonly bent over the square edge of the anvil, a square set-up hammer being held upon its upper surface, and sometimes the work is pinched fast in the vice, and is bent over with the blows of a flat-ended punch or set, applied close to the angle, and then hammered down square with the hammer. Very stout metal is seldom bent, but cut and the angles riveted.

Thin metal is bent to curves by holding one edge and placing the other edge on the beak-iron, around which the sheet is (Figs. 9 and 10)

Fig. 9.

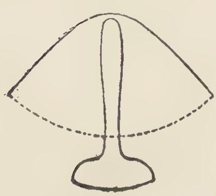
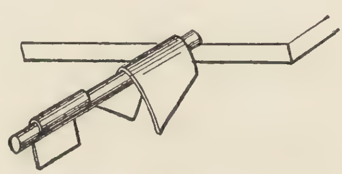


Fig. 10.



curled by the mallet. The crease (Fig. 5) is frequently used for making seams or edging. A strip of sheet metal is laid in the appropriate groove, and an iron wire is driven down upon it by the mallet. The wire, of course, bends the strips when driven down; the edges are then folded down upon the wire by the mallet,

and it is then finished by a punch or top tool (Fig. 11) matching the groove in the crease.

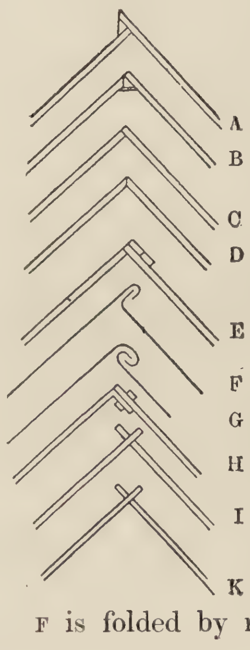
JOINTS.

Let us now glance at the various methods of making joints at angles of sheet metal, as at Fig. 12. A and B are for the thinnest metals, such as tin, which requires a film of soft solder on one or the other side. Sheet lead is similarly joined, and both are usually soldered from within.

FIG. 11.

C and D are the *butt* and *mitre* joints, used for thicker metals, with hard solders. Sometimes D is dove-tailed together, the edges being filed to correspond coarsely; sometimes they are partly riveted before being soldered from within. These joints are very weak when united with soft solder.

FIG. 12.



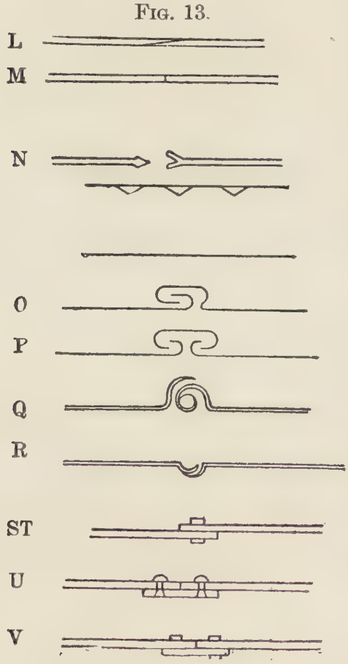
E is the *lap* joint, the metal being creased over the hatchet-stake. Tin plate requires an external layer of solder; spelter solder runs through the crack and need not project. F is folded by means of the hatchet-stake,

the two are then hammered together, but require a film of solder to prevent their sliding asunder.

G is the *folded angle* joint, used for fireproof deed-boxes and other strong work, in which solder would be inadmissible. It is common in tin and copper work, but less so in iron and zinc, which do not bend so readily.

H is a *riveted* joint, which is very commonly used in strong iron plate and copper work, as in boilers, etc. Generally a rivet is inserted at each end, then the other holes are punched through the two thicknesses on a block of lead. The head of the rivet is put within, the metal is flattened around it by placing the small hole of a riveting set over the pin of the rivet, and giving a blow; the rivet is then clenched, and is finished to cir-

Fig. 13.



cular form by the concave hollow in the riveting set.

In I K one plate is punched with a long mortise, the other being formed into tenons, which are inserted and riveted. K, however, has tenons with transverse keys, which can be taken out and the plate released.

Let us now see to the straight joints.

L (Fig. 13) is the lap joint, employed with solder for tin plates, sheet lead, etc., and for tubes bent of these materials.

M is the butt joint, used for plates and small tubes of the various metals. When united by hard solders or brazed, such joints are moderately strong, but with soft solders the joints are very weak, from the limited superficies of the adhering surface.

N is the *cramp* joint. The edges are thinned by the hammer, the one is left plain, the other is notched obliquely with shears for one-eighth of an inch deep; each alternate cramp is bent up, the other down, for the insertion of the plain edge; they are then hammered together and brazed; after which they may be made nearly flat by the hammer, and quite so by the file. The cramp joint is used for thin work requiring *strength*, and amongst numerous others for the parts of musical instruments. Sometimes the lap joint (L) is feather-edged.

This improves it, but it is still inferior to the cramp joint in strength.

O is the lap joint, without solder, for tin, copper, iron, etc. It is set down flat with a seam set, and is used for smoke-pipes and numerous works not required to be steam and water tight.

P is used for zinc works and others. It saves the double bend of the preceding. It is sometimes called the "patent strip overlap."

Q is the roll joint, used for lead roofs.

R is a hollow crease, used till recently for vessels and chambers for making sulphuric acid. The metal is scraped perfectly clean, filled with lead heated nearly to redness, and the whole united by burning with an iron also heated to redness. Solder which contained tin would be attacked by the acid. Now superseded by autogenous soldering.

S T, joints united by screw-bolts or rivets, for iron and copper boilers, etc.

U, united with rivets, in ordinary manner of uniting the plates of marine boilers and other work requiring to be flush externally.

V is a similar case, used of late years for constructing the largest iron steam-ships, etc. The ribs of the vessel are made of T iron, varying from about 4 inches to 8 inches wide, which is bent to the curves by the employment of very

large surface-plates cast full of holes, upon which the wood model of the rib is laid down, and a chalk mark is made around its edge. Dogs or pins are wedged at short intervals in all these holes, which intersect the course; the rib, heated to redness in a reverberating furnace, is wedged fast at one end and bent around the pins by sets and sledge hammers, and as it yields to the curve each pin is secured by wedges until the whole is completed.

Zinc.

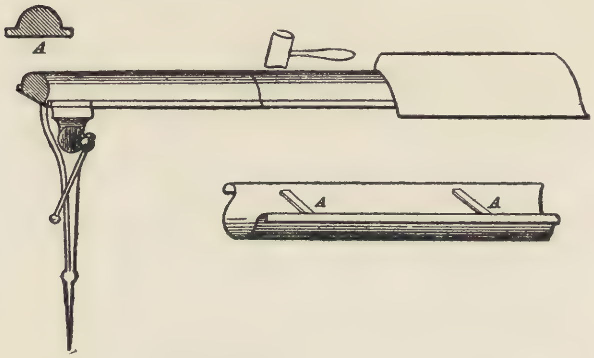
Our illustrations of this metal principally refer to junctions of external rainwater gutters or troughs.

In large towns the gutters and pipes are usually of tin or galvanized iron; but occasionally tin is employed for this purpose.

Gutters are very easily formed of zinc. The slip of the desired width being cut off the roll with shears or knife, is gently hammered to the correct curvature over a mould of wood made to order by the carpenter, something like in section A, Fig. 14, which is screwed up in one or a couple of vices, or otherwise fixed firmly on the shop-bench. When this is done, the trough is turned right way up, and the "stays," which are formed of a small piece of zinc, rolled up round into a kind of close tube, are

soldered across from side to side of the top at intervals (A A, Fig. 14), to hold the trough together and brace it. Of course, the angles at which the guttering joins at any internal or external angles of the roof will be cut to shape before the zinc is curved, and it is in this case that plans of proper cutting out are useful. It must be remembered that zinc is a less pliable metal than lead or copper, or even than tinned

Fig. 14.



iron, and very springy. This last qualification renders it difficult to get zinc to take and retain a new shape when worked cold. But if it be heated over the fire to nearly boiling-point (212° Fahr.) there will be no more trouble on this score. It is not so easy to solder as tin, and rosin is rather uncertain with it. The hydrochloric acid (generally called "muriatic acid") acts better, and so does "Baker's

soldering fluid." The copper bit, well tinned, is the tool used. There are several gas blow-pipes or soldering-jets which act well with moderate care. The surface of the zinc at the joints should be clean and scraped bright. Do not use too much solder.

Galvanized Iron.

This is comparatively a recent material. Of course, ordinary thin sheet-iron has been in use almost from time immemorial, but its range was limited from its excessive tendency to rust, and it was chiefly for such purposes as stove-pipes, etc., that it was applicable. The discovery of coating it with zinc (*i. e.*, "galvanizing" it) has largely added to its utility. In this country there is a large industry for the production of galvanized iron cornices for architectural purposes. Iu place of using cornices and string-courses of stone in the fronts of brick houses, as formerly, we now prefer those of galvanized sheet-iron made in long lengths, and fixed to wooden blocks let into the brickwork, or to suitable rod-iron supports similarly fixed. Some of these cornices, when containing many members of mouldings, especially if they are circular in plan, need much skill. In general the metal is bent over the hatchet-stake with mallet or hammer,

much as in making zinc guttering, assisting with swages where necessary. The following observations on "Circular Work" are by Mr. C. A. Vaile, late Superintendent of the Cornice Works at Richmond, Indiana.*

"In making up circular mouldings, it is necessary to have the material sufficiently heavy to bear shrinking and stretching without breaking or becoming brittle. The best plan for bringing mouldings to the required shape is in the following manner: Take a piece of hard wood (oak) 4 inches by 4 inches and 12 inches long, make a profile of work intended, and on one end of this piece make a die of the desired shape; to this must be fitted a plunger, allowing the thickness of iron to intervene. The die is shown in the following figures: Fig. 15 is the top; Fig. 16 is the sectional view of the plunger and die for a half-round mould. Fig. 15 is to be made in the same circle as work. Figs. 17 and 18 are the same, of a different moulding. Figs. 16 or 18 is to be placed in an oak block, as Fig. 19. The right-hand portion should be of sufficient length to answer for a seat to the operator. Fig. 20 is a mallet about 12 inches long. To make these dies, imagine the cap to be stamped

*Galvanized-Iron Cornice-Worker's Manual. Philadelphia. Henry Carey Baird & Co.

from one piece, and get out the die and plunger accordingly. The tools required will be a saw,

Fig. 15.

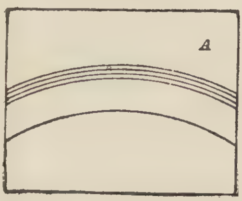
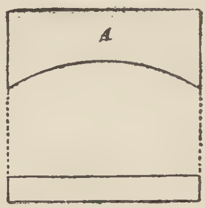


Fig. 16.

Fig. 17.



brace, and $\frac{1}{2}$-inch bit, a straight chisel, two or three sizes of gouges, a straight rasp, and a

Fig. 18.

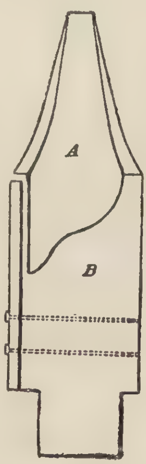


Fig. 19.

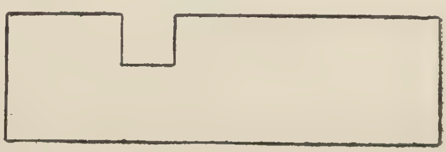
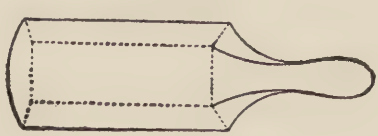


Fig. 20.



rasp curved at one end. When the iron is cut

to the required pattern, it is raised in these dies, shifting the mould to and fro each time, it is forced into the die with a blow on the plunger from the mallet, until it is brought to the required shape. A little practice will soon demonstrate the utility of this method, and also its superiority over the hammering process.

"When work is to be put together, never place two raw edges together. On one of the members turn $\frac{1}{8}$ of an inch edge, and lap the member on this and soak the solder in well, so as to firmly unite the pieces, and on the top strip that is to be built in the wall turn a $\frac{1}{2}$-inch edge, to stiffen and answer the purpose of straps to hold the cap in position. An edge of the same kind should also be turned on bottom strip, to extend over the frame; and if the cap is to have a drop or corbel, let the inside of the drop or corbel extend back past the frame at least one inch, to secure the corbel to the frame, and the other side of corbel have a $\frac{1}{2}$-inch wedge to fit against the wall.

"Should the work be for a building already up, the strip should have an edge sufficient to nail through into mortar joints. Good judgment is required in putting up work of this character to make it a success."

II.

SOLDERING.

Soldering is the process of uniting the edges or surfaces of similar or dissimilar metals and alloys by partial fusion. In general, alloys or solders of various and greater degrees of fusibility than the metals to be joined or placed between them, and the solder, when fused, unites the three parts into a solid mass; less frequently the surfaces, or edges, are simply melted together with an additional portion of the same metal.

The solders are alloys of various kinds, and are broadly distinguished as *hard-solders* and *soft-solders*. The former only fuse at the red heat, and are consequently suitable alone to metals and alloys that will endure that temperature; the soft-solders melt at very low degrees of temperature, and may be used for nearly all the metals.

The forms of soldered joints in the sheet metal have been already given at pages 117 and 118.

The following table exhibits most of the facts necessary to be known relating to the solders

and their use. It contains the composition of the various solders, the fluxes suitable for each, and the manner of applying the heat. This is abridged from Holtzapffel s "Mechanical Manipulations."

"Soldering may be divided generally into two branches, viz., 'hard-soldering' and 'soft-soldering.' The first process may be used with all metals less fusible than the solders, the modes of treatment being nearly similar. The hard-solders used are generally spelter solders, the flux usually borax, A, and the mode of heating the naked fire, the muffle, or furnace, and the blow-pipe (*a*, *b*, *g*). Laminated gold is used for soldering platinum, copper for iron, gold for gold alloys; spelter solders, granulated, for iron, copper, brass, gun-metal, German silver, etc. Soft-soldering is applicable to most of the metals. The methods pursued are very various. The soft-solder mostly used is composed of two parts of tin and one part of lead; sometimes, from economical motives, much more lead is employed, and $1\frac{1}{2}$ of tin to 1 of lead is the most fusible of the group, unless bismuth is used. The fluxes B to G, and the modes of heating *a* to *i*, are all used with the soft-solders. In the following examples the metals to be soldered are placed first, then the number of the alloy to be used

as solder, next the capital letter signifying the flux to be employed, and lastly the italic letter which indicates the mode by which the heat should be applied. (See p. 130.)

"Iron, cast-iron, and steel, 8, B D; if thick heated by *a*, *b*, or *c*, and also by *g*.

"Tinned iron, 8, C, D, *f*.

"Silver and gold are soldered with pure tin or with 8, E, *a*, *g*, or *h*.

"Copper and many of its alloys, namely, brass, gilding metal, gun-metal, etc., 8, B, C, D, when thick heated by *a*, *b*, *c*, *e*, or *g*, and when thin by *f* or *g*.

"Speculum metal, 8, B, D, C; the sand-bath is perhaps the best mode to apply heat, which should be done cautiously.

"Zinc, 8, *c*, *f*.

"Lead and lead pipes, or ordinary plumber's work, 4 to 8, F, *d* or *e*.

"Lead and tin pipes, 8, D and G mixed, *g* and also *f*.

"Britannia metal, 8, C, D, *g*.

"Pewters—the solders must vary in fusibility according to the fusibility of the metal; generally G and *i* are used, sometimes also G and *g* or *f*.

"Burning together is sometimes adopted for brass and iron, and lead is united by pouring on red-hot lead, with the aid of a red-hot iron.

Alloys and their Melting Heats.

No.					Fahr
1	1 tin	25 lead			558
2	1 —	10 —			541
3	1 —	5 —			511
4	1 —	3 —			482
5	1 —	2 —			441
6	1 —	1 —			370
7	1½ —	1 —			334
8	2 —	1 —			340
9	3 —	1 —			356
10	4 —	1 —			365
11	5 —	1 —			378
12	6 —	1 —			381
13	4 lead	1 tin	1 bismuth		320
14	3 —	3 —	1 —		310
15	2 —	2 —	1 —		292
16	1 —	1 —	1 —		254
17	2 —	1 —	2 —		236
18	3 —	5 —	8 —		202

Note.—By the addition of 3 parts of mercury to No. 8 it melts at 122 deg. Fahr., and may be used for anatomical injections and for stopping teeth.

Fluxes.

A Borax.
B Sal-ammoniac or mur. of ammonia.
C Muriate or chloride of zinc.
D Common resin.
E Venice turpentine.
F Tallow.
G Gallipoli oil or common sweet oil.

Modes of Applying Heat.

a Naked fire.
b Hollow furnace or muffle.
c Immersion in molten solder.
d Molten solder or metal poured on.
e Heated iron not tinned.
f Heated copper tool tinned.
g Blow-pipe flame.
h Flame alone, generally alcohol.
i Stream of heated air."

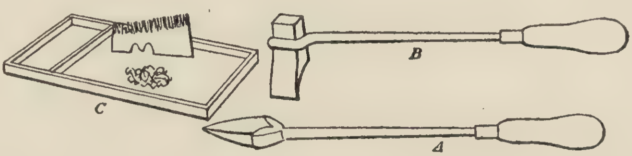
—From the *Mechanics' Manual.*

For the soft-solders, the soldering-iron is the most general agent for applying the heat; for the hard-solder, forge or other fires, or the blow-pipe, are generally adopted. *Brazing* (used with sheet brass and sheet copper) may be defined as soldering with fusible brass, and hence as a form of hard-soldering.

It is necessary that all soft-soldered joints should be very clean and quite free from any metallic oxide. It is therefore the general practice to scrape the adjacent parts for everything except clean tin-plate.

The copper soldering-bit (usually misnamed the "soldering-*iron*") is shown at A, Fig. 21.

FIG. 21.



It consists of a small piece of solid copper riveted between the forked end of a split iron rod, the whole being provided with a wooden handle. Sometimes the copper-bit is made of the form of B, and fixed as there shown. These are usually termed "hatchet-bits" from their shape. All works in tinned and sheet iron, and many of those in copper and brass, are soldered with the copper-bit, which in gen-

eral suffices to convey all the heat required to melt the more fusible solders now employed.

If the copper-bit has not been previously tinned, it is heated in a small charcoal stove, or otherwise, to a dull red, and hastily filed to a clean metallic surface; it is then rubbed immediately, first upon a lump of sal-ammoniac, and next upon a copper or tin plate upon which a few drops of solder have been placed. This will completely coat the tool; it is then wiped clean with a piece of tow, and is ready for use.

The copper "bit," or end, must always, as we have said, be "tinned," or covered with tin, before using. This will always need to be done. Here is another plan: File it bright with a fine file and give it a pointed end, not too sharp, and then put it into your charcoal or coke fire. Get a soft red brick and scoop out a hole about as big as a cherry in its top surface. When the bit is not quite red hot, hold the bar of solder in your left hand over the hole in the brick, and touch it with the hot bit in such sort that the metal drops in the cavity; drop also a pinch of powdered rosin on it. Now rub the bit round and round in the brick until it gets cool, and by that time, if the operation has been properly performed, it will be coated with solder.

In soldering coarse works, when their edges have been brought together they are slightly strewed with powdered rosin, contained for convenience in the side compartment of the box, Fig. 21. The soldering-bit is held in the right hand, the cake of solder in the other, and these being brought into contact, at short intervals, as the hand passes down the seam, a few drops of solder are let fall on the joint here and there. The end of the bit is then applied to the joint and passed along it, so that it fuses the solder and distributes it along all parts of the joint, so as to fill it entirely up. Only a portion of the joints, say about 6 inches or 8 inches, is thus dealt with at a time.

It is very usual to keep two soldering-bits in use, so that while one is in hand the other may be heating in the stove. It is impossible to make satisfactory work unless the tool be kept at a sufficient heat. It should not, however, be raised to too great a heat, or the tinning will be burned off and will need to be replaced.

It is often found convenient to fix the cake of solder upright in the flat box that contains the flux. In this position a few drops can be taken from it on the heated bit. (Fig. 21, *c.*)

Dexterous workmen will often make a good joint by passing the soldering-bit once only along the edge or fold of the metal, and leave

a very fine and regular line of solder. To ensure this, the bit must be kept very thin and sharp at the edge, and the flux must be the muriate of zinc or killed hydrochloric acid (muriatic acid, mentioned on page 122); the joints being moistened with this by means of a skewer previously to the application of the bit.

Copper works are more commonly fluxed with powdered sal-ammoniac, and so is likewise sheet-iron, although some mix powdered rosin and sal-ammoniac; others moisten the edges of the work with a saturated solution of sal-ammoniac, using a piece of cane, the end of which is split up into a kind of brush, and subsequently apply rosin. Each plan has its advocates, and each appears to work well in accustomed hands.

Besides the usual copper-bit, the plumber employs a large heavy bulbous iron in soldering. This is especially used for joints in lead pipe, which require to be very sound. These are generally extremely clumsy in appearance, as by the aid of the hot iron and a piece of tick held in the left hand the plumber manages to plaster a great bulbous patch of solder round the point of junction, which they term a "wiped" joint.

The blow-pipe (mouth) is used to some de-

gree in soft-soldering, principally by the gas-fitter, who is generally remarkably expert in making joints in his composition pipes therewith. These are not made like the plumber's, by inserting one end of the pipe in the other and plastering a bulb of solder around the place, but by cutting off the pipes with a fine saw and filing them up square and smooth to butt together into a mitre or a T-joint. These joints have frequently to be made in very awkward and confined situations amongst joists under floors, etc., and are generally effected by applying by some convenient means the heat from one side only, and forcing the flame thus obtained upon the joints with a blowpipe. They generally use a rich tin solder, and employ a flux of oil and rosin in equal parts.

The pewterers generally use the hot-air blast, by means of a peculiar cast-iron apparatus employed only in their trade. They use fusible solder containing bismuth, and for flux a common green olive oil termed Gallipoli oil.

For hard-soldering an intense fire-heat is required, similar to that obtained in the smith's forge. In fact, the ordinary blacksmith's forge is frequently used for brazing, although the process is injurious to the fuel as concerns its normal purpose.

The brazier's hearth, for extensive works, is generally a plate of iron about 4 feet by 3 feet, supported on four legs at its corners, and with a central opening about 2 feet by 1 foot and 6 inches deep for the fuel. The blast is generally supplied by a fan, and the tuyere-irons have large apertures.

Fresh coal should never be used, but charcoal, or, failing that, coke or cinders. Lard in the fire is very prejudicial.

In all cases of hard-soldering or brazing the meeting edges are to be scraped or filed clean (especially when the heat used will not reach the *red* degree). The work in copper, iron, brass, etc., having been prepared and the joints retained in position by binding with iron wire when needful, the granulated spelter and powdered borax are mixed in a cup with a very little water, and spread along the joints by a slip of sheet metal or a small spoon.

The work is now placed above the clear fire, first at a small distance to gradually evaporate the moisture and deprive the borax of its water of crystallization. During this process the flux boils up with a frothy look, and sometimes shifts the solder away. The heat is now increased, and when the metal assumes a faint red the borax melts like glass. As the metal gets deeper red the solder fuses also, generally

with a slight blue flame if it contains any zinc. Generally at this point the solder "flushes" or disappears in the work. Should it not do so, and appear refractory on the score of running into the joint, the work may be tapped with the tongs, in order to make it move. Care must, of course, be taken that the heat is not so much raised as to melt the work as well as the solder. If the work be iron, there is, of course, little need of precaution.

If it is iron which you wish to braze, you have to file the meeting surfaces bright; make a little borax into a paste with water, and smear them over with this. Next tie them together with some fine iron wire, just enough to prevent the pieces from coming apart. Then wind them round and round at the place of the joint with several coils of fine brass wire, rubbing them over with the borax paste. This is then laid on the fire and the blast put on. Presently a small blue flame will be seen reflecting over the place. This is a sign that the brass wire is melting and that the heat is dissipating the zinc constituents of the brass, and the brass having melted and run into the joint the job is done.

It is only iron, however, to which you can apply so much heat. For brass and copper you must have a more fusible metal than

brass. This solder is called "spelter" (incorrectly), and is composed of copper and zinc in equal parts. Indeed it is a very soft kind of brass, and liquefies at a much lower temperature than would melt copper or ordinary brass. There are two varieties of spelter, hard and soft, both procurable at any metal warehouse.

The borax (borate of soda) can be got at the same place, or at a druggist's. We have mentioned its quality of swelling up when heated, and that this swelling displaces the solder on the work. In order to obviate this it is not unusual to heat the borax previously, till this considerable swelling up has subsided and the water of crystallization is driven off, when it can be pounded and kept in a stoppered jar.

The blow-pipe is largely used in hard-soldering and brazing, especially for work in the precious metals.

The ordinary blow-pipe is a light conical brass tube, about 10 inches or 12 inches long, from $\frac{1}{2}$ inch to $\frac{1}{4}$ inch in diameter at the end for the mouth, and from $\frac{1}{16}$ inch to $\frac{1}{50}$ inch at the aperture or jet. The small end is bent in a quadrant that the flame may be immediately under observation. Very usually it is fitted with a small hollow brass ball just below the

quadrant, to serve as a receptacle for the condensed vapor from the lungs. This instrument is generally used with a lamp of a wick from $\frac{1}{4}$ inch to 1 inch in diameter and produces a flame of great heat, the object exposed to it being generally placed upon charcoal.

Gas is frequently used in conjunction with the blow-pipe, and this is especially useful for sheet brass, the work being held in place by wire ties if necessary, and either laid upon a flat piece of pumice-stone or held in a pair of pliers.

III.

GEOMETRY AS APPLIED TO SHEET-METAL WORKING.

The utility of a tolerable knowledge of practical geometry to those engaged in the sheet-metal trades scarcely needs be insisted upon. It is next to impossible to strike difficult patterns by mere rule of thumb, and although in many workshops templates may be found for the great number of ordinary patterns, still, even then, occasions will certainly arise for the construction of others for special work. Besides, in the present days of technical instruction and active competition no young man who desires to excel in his trade should be content without the best knowledge available about it. If he will take the trouble, however, to acquire a certain amount of geometrical information, he will be prepared for all emergencies. He will be enabled to work from the roughly-drawn outline sketches of a customer with the same unfailing certainty as if the job was one which he had executed hundreds of times instead of being, perhaps, quite new to him. And besides having the pleasant conscious-

ness of mastery of his work, the artisan will effect a considerable saving in time, material, and temper on many occasions.

The subject appeals to every worker in sheet metal in a greater or less degree. In the manipulation of tin, sheet iron, zinc, copper, lead, and brass it is brought into practice.

The geometrical process mainly called in by the sheet-metal worker is that known technically as the "development of solids;" in other words, the representation on a plane of the exterior surface of a cylinder, cone, prism, or many-sided figure. But, besides this, the manner in which such solid bodies are cut, and the "sections" thus arising and their intersections are not less necessary to be studied, as will become apparent as we proceed.

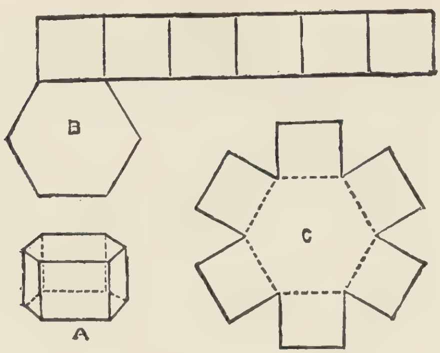
In many cases the sheet-metal worker's pattern or template for a certain job is simply a development of the geometrical form of the article. If it is one (as is usually the case) which requires to be soldered or brazed together, and there are two or three possible ways of cutting the pattern, the operator will select that whereby he may, as far as possible, reduce such joints. Thus, take a hexagonal-sided tin or sheet-iron box shown at A (Fig. 22). For the purpose of the artisan it may be developed into either the pattern shown at B

or that at C. The saving of time effected over cutting its sides and bottom into separate pieces is evident.

Let us now, to render our purpose more plain, detail the process to be pursued in "developing" one of the simplest of the geometrical solids, namely, the cylinder.

When the surface of a cylinder is developed a right-angled parallelogram (all the geometri-

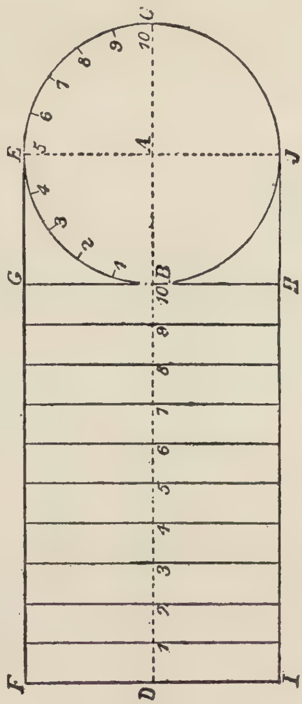
Fig. 22.



cal terms will be explained as we proceed) is obtained, as at F G H I (Fig. 23), the height of which, G H, is equal to the length of the cylinder, which we will imagine in this case to be equal to the diameter of the cylinder, and the length, F G or H I, is equal to the length of the circumference of the circle, as B E J C. The development of this cylinder will indicate the principle upon which all problems of this

kind are based. Let it be required to have the surface of a half-cylinder, as B E C, developed, the height, B G or F D, being equal to the radius, A C. Through A draw the diameter, B C, and extend it indefinitely, as to D; from E draw parallel to C D a line E F, and from B a line at right angles cutting E F in G. Divide the semi-circumference, B C, into any number of equal parts, as ten in the present case. From B on B D set off these parts to D, from it draw D F at right angles to B D; then F D, B G is the development, or "stretch-out," as it is frequently called, of the semi-cylinder, B E C, and if cut out and wrapped around the said half-cylinder would exactly cover it. If the entire cylinder, as at B E C J, needed to be developed, the "stretch-out" would be twice that of B D, F G.

Fig. 23.



Again, let us suppose that it is required by the zinc worker to make a mitre-joint at right angles in a half-round rain-water gutter, or trough. He will proceed geometrically as fol-

Fig. 24.

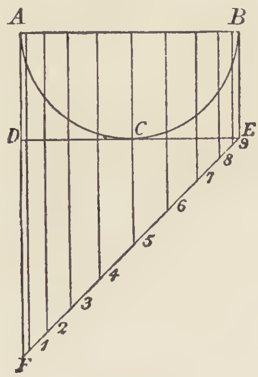
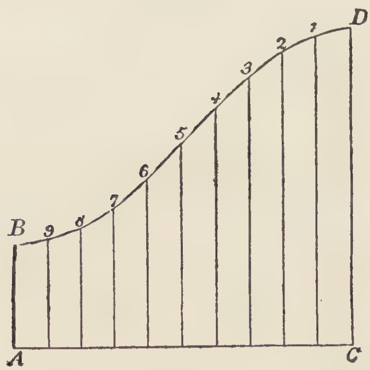


Fig. 25.



lows: Let the semi-circle A B C (Fig. 24) represent the sectional outline of the gutter. Draw the line A B, and draw the lines A F and

B E at right angles to A B, also draw the line D E parallel to A B. Make D F equal to A B, and draw the line F E. Divide the semi-circle into any number of equal parts (in the present case ten). Draw lines parallel to A F through these points in the semi-circle, as at 1, 2, 3, 4, etc. Next draw (Fig. 25) A C equal in length to the semi-circle, A C B (Fig. 24). Draw the lines A B, C D (Fig. 25) at right angles to A C, and make A B (Fig. 25) equal to B E (Fig. 24), and C D in the former figure equal to A F in the latter. Set off on the line A C (Fig. 25) the same number of equal distances as the semi-circle was divided into. Draw lines parallel to C D (Fig. 25) from each point of division, as 1, 2, 3, 4, etc., and make each of these of equal length to the line correspondingly numbered in Fig. 24. Finally trace the curved line B D (Fig. 25), through the extremities of these lines, and the required pattern of the mitre-joint will be obtained.

As in many other cases, there is a certain amount of preliminary dry details to be mastered before the subject can be fairly approached. It is just these preliminary, simple and apparently needless processes that often disgust the learner.

He is apt to think that the special knowledge he desires to gain can be attained by a

" hop, skip and jump " over these—hey, presto ! —to the point which appears to him useful and practical.

This is the greatest of mistakes. It is as if a child should hope to learn to read without first painfully acquiring the alphabet. There is no royal road to any knowledge, although care on the part of an instructor may help to smooth the roughness of the way, and this, in the present instance, we shall endeavor carefully to do.

Let us now speak of the tools required, that is, the appliances to enable us to draw the various diagrams.

These are neither numerous nor costly. The following will be sufficient for the present: A drawing-board of seasoned pine (any board perfectly square at its angles will do), a T-square, two set squares, a flat foot-rule with scales, a pair of compasses with moveable leg for pencil, a protractor, a drawing-pen, a pair of dividers, a couple of black-lead pencils (H and HB or F), and a dozen drawing-pins. The entire outfit need cost but a trifle. We will speak of the use of the instruments as we proceed. Stout cartridge paper is the best for the purpose.

Before proceeding to teach our readers to construct the various figures most usually required in the trades comprehended by the

title of this book, it is requisite that certain terms used in geometry should be explained, as without a good understanding of these our subsequent instructions will not be properly comprehended. We wish our readers to clearly understand that we do not profess in this lesson to teach them the science of geometry, or the art of practical geometry, but merely to illustrate so much of the latter as is applicable to certain special purposes.

It would be infinitely to the advantage of every artisan concerned in these trades to make himself master of the rudiments of geometry. An elementary work on the subject can readily be gotten, and can be mastered in a month.

But to proceed with our terms or definitions:

A *point* simply marks position. Theoretically it is said to have no magnitude or size. Practically the smallest point or dot that we can make *has* size, and therefore is really a *surface*, and not a point. A mathematical point would be the centre of a dot of ink, etc., but for practical purposes the dot itself is spoken of as the point. Sometimes a point is represented by a dot with a small circle around it.

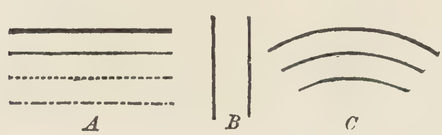
Lines.

A *line* has, theoretically, length or direction only, without breadth. We all know that the

finest line which we can produce by a pen or any tool has some breadth. This is not, therefore, the mathematical or ideal line, although we call it a "line" for the convenience of practical purposes.

A *straight line* or *right line* is the shortest distance from one point to another. In drawing, heavy lines are called "strong," and light ones "fine." Dotted lines are also used for various purposes. Those formed of different-sized dots (principally employed on plans) are termed "chain lines." At A (Fig. 26) the top

FIG. 26.



line is "strong," the next "fine," the next "dotted," and the lower one "chain."

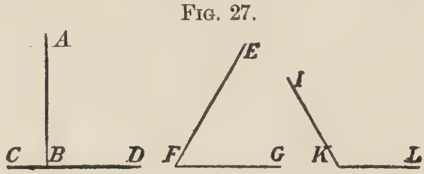
To *produce* a line signifies to lengthen it at either end.

A *curve* or curved line constantly changes its direction, and is, therefore, nowhere straight (C, Fig. 26). Curves are infinitely variable, and may be *simple* or *compound.* Curved lines may be parallel. When they are parts of different circles struck from the same centre they are termed *concentric* (C, Fig. 26).

Parallels or *parallel lines* are those which are everywhere the same distance apart, and which if *produced* or lengthened forever would never meet (see A and B, Fig. 26).

A *horizontal* line is one perfectly level, a *vertical* line is one perfectly upright, having regard to the horizon, as, for example, the line of a plumb-bob. A *perpendicular*, or *perpendicular line*, is one that is vertical or at right angles to some other line. It is not necessarily *vertical* in the strict sense, but may incline to or even be parallel with the horizon line. (The

FIG. 27.



horizon is the line where sea and sky appear to meet when one looks from the shore.) It is thus clear that while a vertical line is perpendicular to a horizontal one, a horizontal line is perpendicular to a vertical one. The line A B, Fig. 27, is perpendicular to the line C D. An *oblique* line is one neither vertical or horizontal, but slanting in regard to some other line, as E F and I K (Fig. 27.)

ANGLES.

An *angle* (from the Latin *angulus*, " a

corner") is formed by the inclination of two lines until they meet in a point called the *vertex* of the angle. The magnitude or size of an angle does not depend upon the length of the lines forming it, but upon their inclination to each other. Thus in an angle of 45° (or any other number) the lines may be an inch in length or may be *produced* or lengthened to a foot or a yard without affecting the angle, which still remains one of 45°.

A *right* angle is one formed by one straight line standing upon or being perpendicular to another. Thus the line A B (Fig. 27), being perpendicular to the line C D, both the adjacent angles are right angles and equal. This is the angle of 90°.

An *acute* angle is sharper or less than a right angle, as at E F G (Fig. 27).

An *obtuse* angle is blunter or greater than a right angle, as at I K L (Fig. 27).

Triangles.

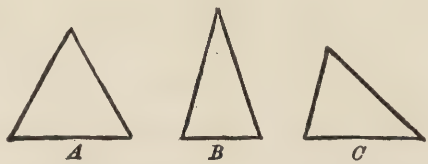
Triangles are figures bounded by *three* straight sides, and having in consequence *three* angles. They are also termed trilateral (meaning "three-sided") figures. There are six varieties of triangles, three named with reference to the length of their sides, and three with regard to the sizes of their angles.

The first three are·

The *equilateral* triangle, which has its sides equal (A, Fig. 28). The angles are also equal, and each contains 60°.

The *isosceles* triangle (B, Fig. 28), which has two sides equal. These sides may be longer or

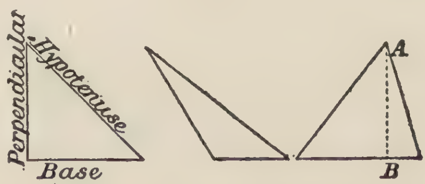
Fig. 28.



shorter than the third side. The unequal side is always termed the *base*, in whatever position the triangle may be represented; the angles at the base are equal to each other.

A *scalene* triangle (C, Fig. 28) has all its sides and angles unequal.

Fig. 29.



The second division of angles embraces:

The *right-angled* triangle (left-hand figure of Fig. 29). The side opposite the angle is called the *hypotenuse*, the others being termed the *base* and *perpendicular*, as shown. These

terms remain the same in whatever position this triangle is placed.

The *obtuse-angled* triangle (central figure of Fig. 29) has one obtuse angle.

The *acute-angled* triangle (right-hand figure of Fig. 29) is that which has three acute angles.

Although we have specified six kinds of triangles it will become clear that, on a little consideration, one of the three latter kinds must also belong to one of the three former classes. In this manner a right-angled triangle must be either an isosceles or a scalene triangle, and an acute-angled triangle may be also an equilateral, isosceles, or scalene triangle.

The highest angle of a triangle is termed its *vertex* (in the plural *vertices*), or *apex* (plural *apices* or *apexes*), or *vertical angle;* the lowest side is called the *base.* With the exception of the isosceles and the right-angled triangle (see page 151), the terms just given are applied to each angle that may be uppermost, or each side that may be lowest when the position of the triangle is altered.

The *altitude* of a triangle is a straight line drawn from the apex to the base, as at A B (Fig. 29).

Any two sides of a triangle, if added together, are greater than the remaining side. It would

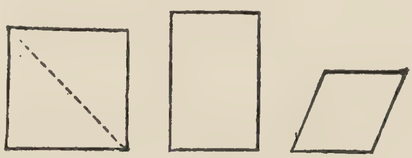
hence not be possible to form a triangle whose respective sides were, say, 4 inches, 6 inches, and 10 inches in length.

The three angles of a triangle when added together always equal 180°, or the half of a circle.

Quadrilateral Figures.

Quadrilateral figures are those bounded by four straight sides. They are also called *quadrangles* or four-angled figures. Their united angles always amount to 360°, or four right angles. If the opposite sides of a quadrilateral are parallel to each other it is termed a parallelogram.

Fig. 30.



The *square* (left-hand figure, Fig. 30) is a parallelogram of four equal sides and four equal angles. A line drawn across a parallelogram from opposite corners is called a *diagonal.*

The *rectangle* or oblong (centre figure, Fig. 30) is a parallelogram, all of whose angles are equal, but only its opposite sides are equal.

The *rhombus* (right-hand figure, Fig. 30) is a parallelogram with four equal sides, having

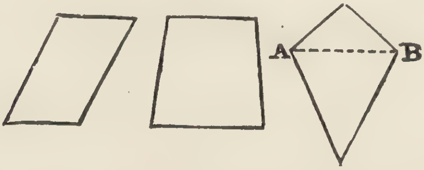
two obtuse angles opposite to each other, and two acute angles opposite to each other.

The *rhomboid* (left-hand figure, Fig. 31) is a parallelogram having only the two opposite sides equal and also the opposite angles equal.

The *trapezoid* (centre figure, Fig. 31), has two parallel sides only, but may have some of the sides or some of the angles equal to each other or not.

The *trapezium* (right-hand figure, Fig. 31), has none of its sides parallel, but some of the sides and some of the angles may or may not be equal to each other, or all the sides and the angles may be unequal. A

Fig. 31.



trapezium, one of whose diagonals will divide it into a couple of unequal isosceles triangles (see A B, Fig. 31) is called a *trapezion* or *kite.*

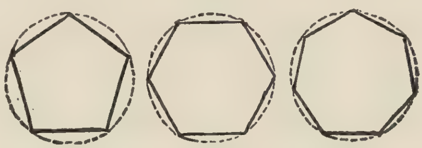
A *polygon* is a rectilinear or straight-lined figure, bounded by more than four straight lines. Polygons are sometimes called multilateral (or "many-sided") figures. They may have any number of sides.

A *regular* polygon has all its sides and angles

equal, and can always be so surrounded by a circle, that the circumference thereof shall pass through all the angles of the polygon. The forms shown at Fig. 32, are regular polygons, that on the left being a pentagon, that in the centre a hexagon, and that on the right a heptagon.

An *irregular* polygon may have unequal sides and equal angles, or equal sides and unequal angles, or neither may be equal.

Fig. 32.



Polygons are named according to the number of sides they possess. A polygon may have any number of sides, but for general purposes is seldom found with more than 12 sides. A Polygon having 5 sides is a Pentagon; 6, Hexagon; 7, Heptagon; 8, Octagon; 9, Nonagon; 10, Decagon; 11. Un-decagon; 12, Do-decagon; 13, Tri-decagon; 14, Tetra-decagon; 15, Penta-decagon; 16, Hexa-decagon; 17, Hepta-decagon; 18, Octa-decagon; 19, Nona-decagon; 20, Bis-decagon; 21, Un-bis-decagon, etc.

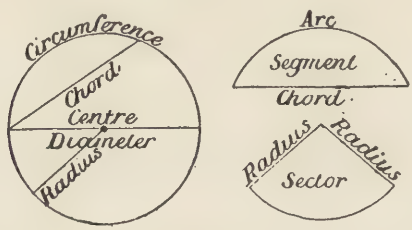
Irregular *polygons* have the same names, but the word "irregular" is added.

The *circle* is a plain figure bounded by one

continuous curved line called the *circumference;* every portion of which is equidistant from a point which is called the centre (see Fig. 33).

The *radius* (plural *radii*) is a straight line drawn from the centre to any point in the circumference; the *diameter* is a straight line drawn through the centre and terminating at the circumference at each extremity. A diameter divides a circle into two equal portions, called semi-circles. The *arc* is a portion of the circumference of any circle.

Fig. 33.

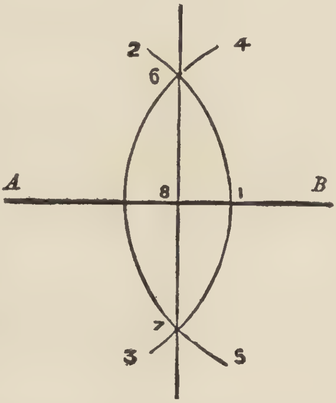


A *chord* is any straight line drawn across a circle which does not pass through the centre; a *segment* is a slice cut off from a circle by a chord; a *sector* is a portion of a circle enclosed by an arc and two radii. When that portion is exactly the fourth part of a circle, it is also called a quadrant.

A *tangent* is a straight line drawn outside of a circle, and which just touches the circumference in one point; in other words, it does not cut off a portion of the circle.

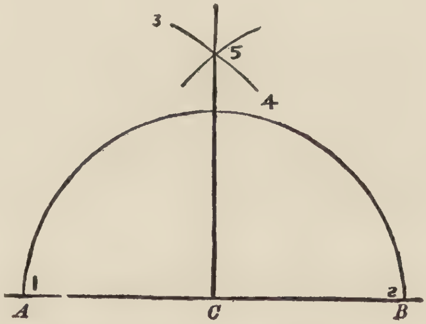
To *bisect* (divide equally) any given straight line, as A B (Fig. 34): Take the compasses, and with the centre A, *describe* (that is, draw) the arc of a circle 2, 3. With the centre B and the same radius, describe the arc 4, 5, *cutting* (or crossing the first arc at 6 and 7. Lastly, through the points 6 and 7 draw the *right* (or straight) line shown, and this will bisect the line A B in the point 8, and be perpendicular to the line A B.

Fig. 34.



From a given point, as C (Fig. 35), to draw

Fig. 35.

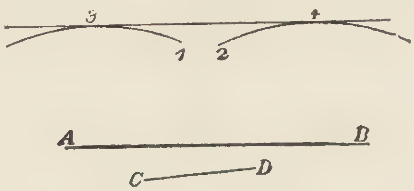


a line perpendicular to A B: With C as centre,

and any radius, mark off the points 1 and 2 at equal distances from C. With 1 as centre, and any radius, describe the arc 3, 4; with 2 as centre and the same radius, cut this arc at 5. Join this point 5 and C by a right line, and this line will be perpendicular to A B and at right angles thereto.

To draw a line parallel to a given line, A B, and at a given distance, equivalent to C D, (Fig. 36):—From it, with the centres A and B respectively, and the distance C D as a radius,

Fig. 36.



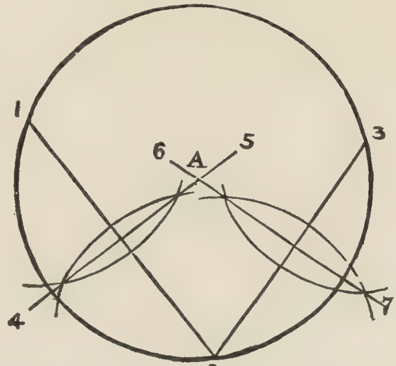
describe the arcs 1 and 2. Draw the line 3, 4, resting upon these arcs at their highest point, and this line will be parallel to A B and at the required distance from it.

To find the centre of any given circle or arc of any circle: Draw any two chords, as 1, 2 and 2, 3 (Fig. 37). Bisect each chord by a perpendicular (this can be accomplished by the means indicated at page 157 for bisecting a right line), and produce these perpendiculars 4, 5 and 6, 7, until they intersect at A. The point

A thus found is the centre of the required circle.

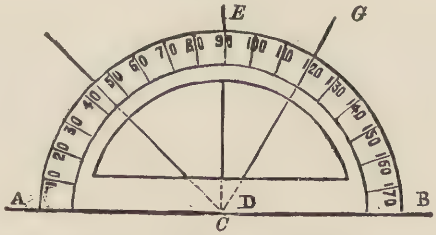
We have spoken before of angles (see page 149), and it may be well here to allude to the

Fig. 37.



manner of measuring them by instruments. The circumference of a complete circle contains 360°; a semi-circle 180°, and a quadrant

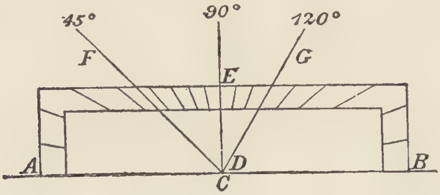
Fig. 38.



(or quarter-circle) 90°. If, then, we take a semi-circle of thin brass and divide it into 180 equal parts we form a protractor (Fig. 38), or

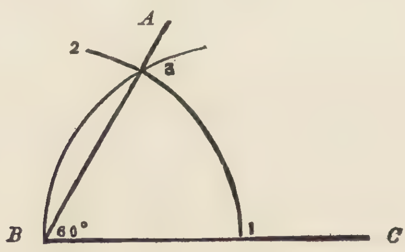
instrument for measuring angles in drawings, etc. Let A B be the base line, from which ascends a line C E. If we apply the lower straight edge of the instrument to the former line, and bring the small nick or mark in the

FIG. 39.



centre of its straight side to C, we shall find that the line E D C cuts the circumference of the protractor at 90°; E C B is, therefore, an angle of 90°, or a right angle. Similarly F C A is an angle of 45°, or half a right angle, and

FIG. 40.



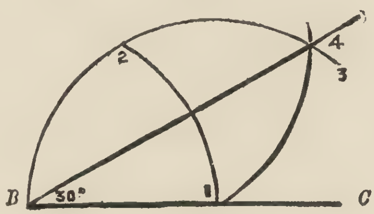
G C B is an angle of 60° (the mark ° indicates a degree or degrees), and G C A is an angle of 120°. Sometimes the protractor has the form of a parallelogram, as at Fig. 39, but its use is

the same. A protractor of one of these forms is generally found in every box of instruments.

To draw an angle of 60° geometrically: With centre B (Fig. 40), and any radius, describe the arc 1, 2. With centre 1, and the same radius, describe the arc B 3. Draw the right line, A B, through the point found by the intersection of the arcs, and A B C is an angle of 60°.

To draw an angle of 30° geometrically:

FIG. 41.

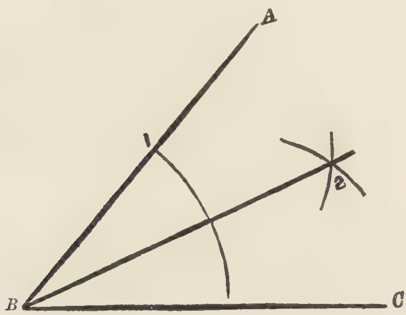


With centre B (Fig. 41) describe the arc 1, 2. With the centre 1, and the same radius, describe the arc B 3. With centre 2, and the same radius, describe the arc 1, 4. Join B 4, and the angle A B C is an angle of 30°.

To bisect (divide into two equal angles) any given angle, as A B C (Fig. 42): With B as centre and any radius, describe the arc 1; with 1 as centre, and any radius, describe the arc 3; with the opposite point as centre, and the same radius, cut the arc 3 at 2. Join B 2, and the

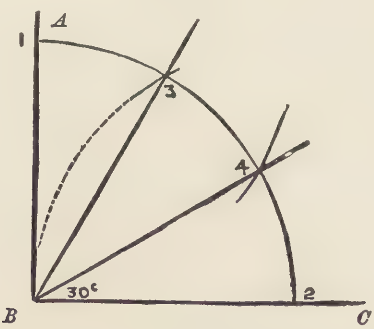
line B 2 will bisect the angle A B C—that is to say, the angle A B 2 will be equal to the angle 2 B C.

FIG. 42.



To trisect (divide into three equal angles) a right angle A B C (Fig. 43): With centre B, and any radius, describe the arc 1, 2; with the centres 1 and 2, and the same radius, describe

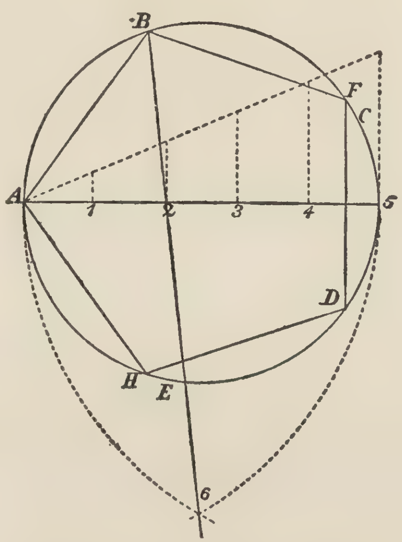
FIG. 43.



the arcs 3 and 4. Draw B 3 and B 4, and the right angle will be trisected or divided into three equal angles.

In a given circle to inscribe any regular polygon, say a pentagon. One method: First draw the diameter A 5 (Fig. 44), and divide it into as many equal parts as it is required that the polygon should have sides (in the present instance five). With points A 5 as radius describe arcs intersecting each other at 6. From 6 draw a line through point 2 to B. Join A B,

Fig. 44.



which is one side of required polygon. Mark off distance A B from B to F, from F to D, and D to H, round circumference. Join B F, F D, D H, and H A, and these lines will all be equal,

and the figure will be the required regular polygon; in this instance a pentagon.

By this plan a regular polygon having any desired number of sides can be inscribed within a given circle. If, for instance, it was required to inscribe an octagon, the student would divide the diameter into eight equal parts, and then proceed as above; but to obtain the first side of the polygon he would invariably draw a line from point 6, though the second division of the diameter, no matter how many sides the polygon was to have. The centre of a polygon coincides with the centre of the circumscribed circle. In any polygon having an even number of sides a line drawn from one angle to the angle opposite (which would be a diagonal) must go through the centre. When there are odd sizes, a line drawn from any angle, through the centre, bisects the side opposite.

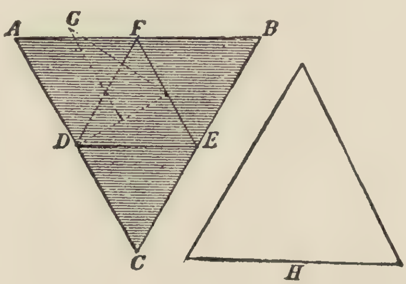
The development of regular solids, or polyhedrons (viz., "many sided" figures), which are bounded by planes, is very simple and easy. Indeed, in most instances the instincts of the operator could scarcely fail to guide him aright. Still, in order that our lessons may be tolerably complete, we think it is just as well to advert to the subject here.

All solids having plane (or "flat") surfaces must form "solid" angles where their faces

unite. And as three plane angles at least are required to form a solid angle, it follows that the most elementary and simple of the solids is a pyramid whose base is triangular, and whose sides are formed by three triangles, which unite in the angle at the apex, or top, of the pyramid.

The "stretch-out" of this solid (H, Fig. 45) is obtained by first describing the *equilateral* triangle, D F E, by the method previously ad-

Fig. 45.



verted to, and then erecting on the three sides or base lines the three triangles D A F, F B E, and D C E (Fig. 45), whose surfaces are inclined when the development is closed up, so that the three triangles meet at the apex G.

The solid just spoken of is the simplest of the five regular polyhedrons. It is termed, geometrically, a *tetrahedron*, or "four-sided" figure.

The next most simple solid is the cube (A, Fig. 46). This is known by the geometrical name of a *hexahedron*, or "six-sided"

Fig. 46.

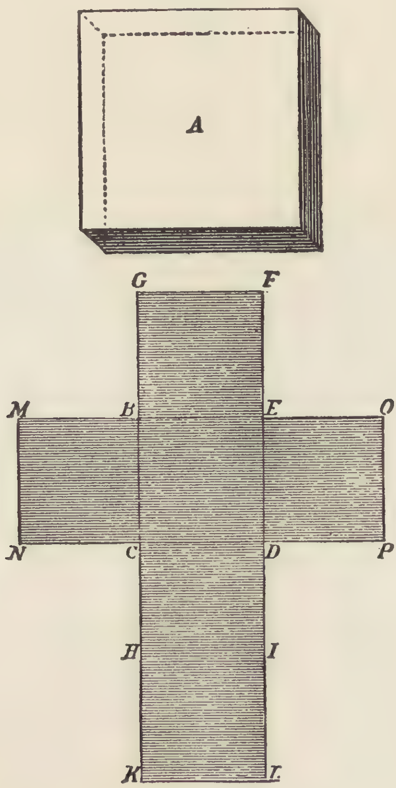
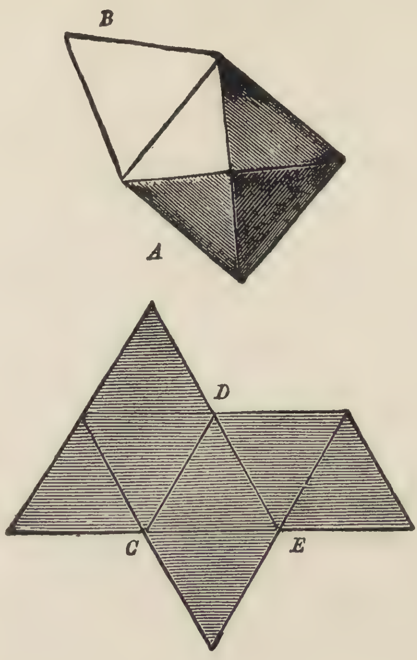


figure. The development (shown also at Fig. 46) needs no explanation. A square, C B E D, is first formed by any process, and the adja-

cent squares B G F E, M N C B, E O P D, and C D H I, added to its sides, the last side being completed by the addition of the square H I K L (Fig. 46).

The *octahedron*, or "eight-sided" figure (A, Fig. 47), is composed of eight equilateral

Fig. 47.

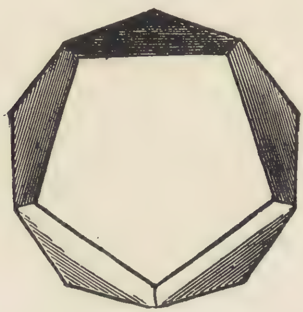


triangles as shown. One face, C D E, having been constructed in the usual manner, the other seven sides are subsequently added, as

shown at Fig. 47. (One face has been omitted in engraving.)

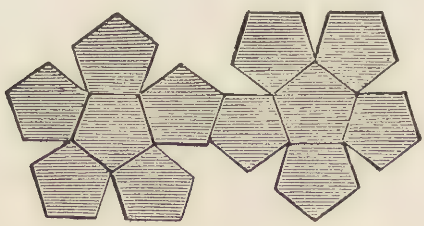
The next regular solid is the *dodecahedron*, or "twelve-sided" figure (Fig. 48). The faces

Fig. 48.



of this solid are composed of twelve regular pentagons (or "five-sided" figures, and it is

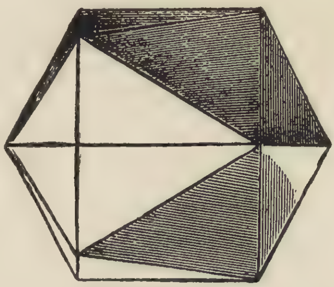
Fig. 49.



hence necessary to construct a pentagon according to any approved method, and then form others on its sides in the manner shown at Fig. 49.

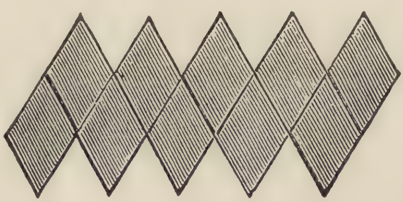
The last regular polyhedron is the *icosahedron* (Fig. 50), which is bounded by twenty equilateral triangles. For obtaining the "stretch-out" these may be arranged as shown at Fig. 51.

Fig. 50.



All the preceding developments, if cut in card-board, scale-board, or thin metal, will, when their edges are brought together, assume the appearance of regular solids.

Fig. 51.



Although the equilateral triangle, the square, and the pentagon are the only figures from which can be formed regular polyhedrons whose angles and sides are equal, yet by

cutting the solid angles of the said polyhedrons in a regular manner, we can obtain regularly symmetrical solids whose sides are formed of two similar faces. Such is, for example, the polyhedron of eight sides obtained by cutting equally the angles of a tetrahedron. Of these eight faces four are hexagons (or "six-sided" figures), and four are equilateral triangles. In the same manner if we cut the solid angles of the cube regularly we obtain a polyhedron of fourteen sides, viz., six octagonal (or "eight-sided") faces and eight triangular.

The octahedron, similarly dealt with, gives also a polyhedron of fourteen faces—six square and eight octagonal.

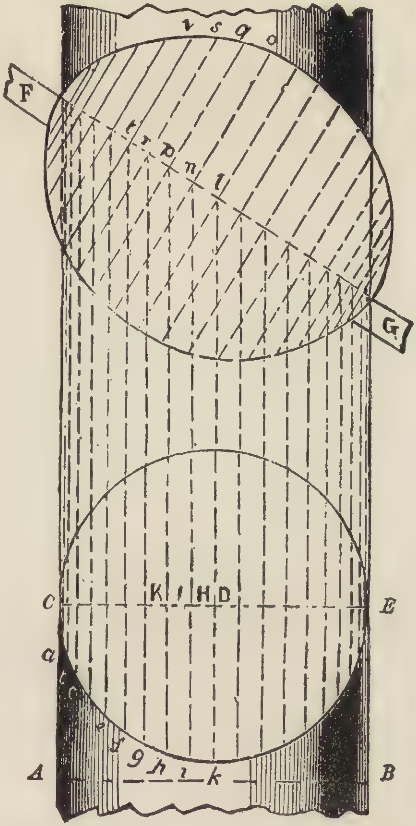
The dodecahedron, when thus cut, yields a solid of thirty-two sides, of which twelve are pentagons and twenty are hexagons.

We have already given the method of getting the stretch-out of a cylinder from the circumference, and now present another problem having to do with cylindrical bodies and exemplifying the use of ordinates.

The sections obtained by cutting a cylinder otherwise than longitudinally, or at right angles to its length, are of considerable importance in many works. Fig. 52 shows how to get at the figure produced by cutting a cylinder in a diagonal or slanting direction. If we cut a

cylinder at right angles to its length, or, in other words, parallel to its base, as at C E (Fig. 52), we get a circle; but if we cut the cylinder

Fig. 52.



obliquely to its base, as at F G (Fig. 52), the section produced is an ellipse. In many cases a knowledge of the method of finding the pre-

cise form of the ellipse produced by such oblique cuttings of a cylinder is of considerable importance to the artisan, and this we proceed to describe.

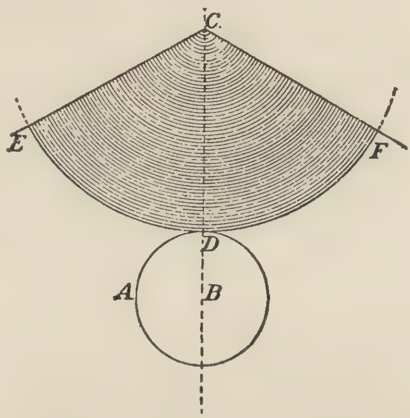
Let A B C E (Fig. 52) be a cylindrical pipe, or tube, or rod, which has to pass through some flat surface (as a roof, ceiling, iron-plate, etc.), F G, which lies obliquely to the base of the pipe, or tube, and let it, moreover, be desired to find the form of ellipse that will need to be made or perforated in such roof or plate, to allow it to pass through. Through H (Fig. 52) draw C E at right angles to C A and E B respectively. Divide the semi-circumference C *a b c d e f g h i k* E into any number of equal parts (the more the better, as the ordinates will give a greater number of points through which to trace the curve of the ellipse). From the points thus obtained in the circumference draw lines parallel to C A or E B, as *k i h g*, etc., cutting the line C E in the points D H I K, etc., and produce them until they cut the diagonal line F G in *l n p r*, etc. Next, from the latter points, and at *right angles* to F G, draw the lines *l m*, *n o*, *pq*, *rs*, etc. Then from D measure to the semi-circle, and set off this distance from *l* to *m* on the line *l m*. Next measure from H to the semi-circle and set the distance off from *n* to *o* on the line *n o*. In the same

manner transfer the other distances to *p q*, *r s*, etc. Repeat these operations upon the other side of the line F G. Finally, through the points thus obtained draw the ellipse by hand.

Now let us treat of the cone and its development.

A cone may be produced in any thin ma-

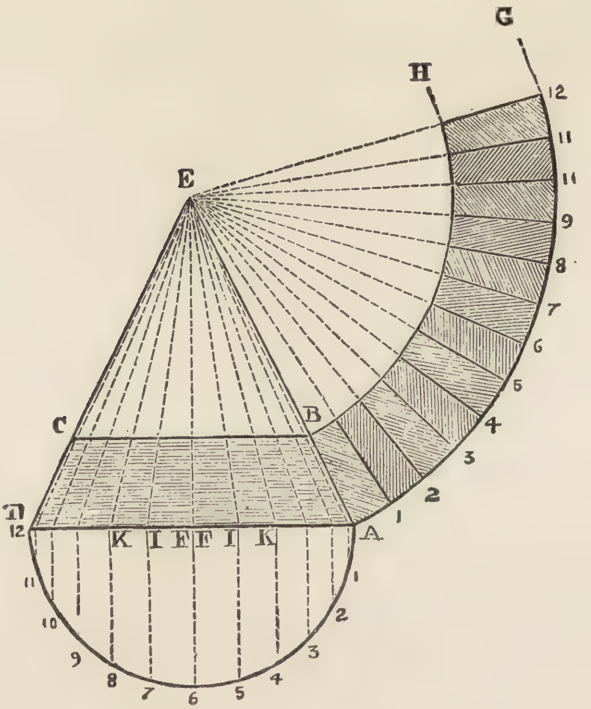
Fig. 53.



terial, as shown in Fig. 53. Let A be the circle of the base; through B, its centre, draw a line B C; make E C equal to the length of the sloping side; from C with C E, describe the arc E D F; take, in inches, or in parts of inches, the radius B D of the base, and multiply by 180°, and divide it by the number of parts there are in C E, the length of the slanting side.

The result is the angle with the sloping side, as C E makes with the centre line C D. In the example there are two parts in the radius B D, and six in the length of side, which gives the

FIG. 54.



angle, E C D, of 60°. From C, with a chord of 60°, describe the arc E F and set off 60° from the same scale of chords from E to D; draw C D and

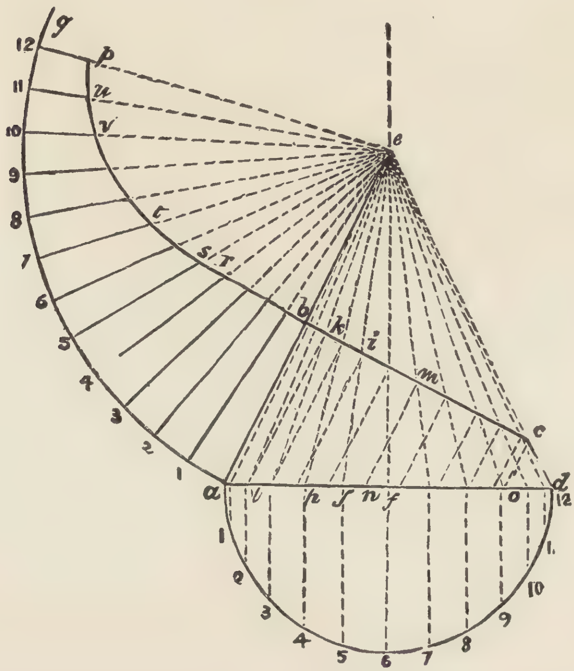
make C F equal to C E; join C F. Then bend the outline E F till the edges C F E meet, the edge E D F passing round the periphery of the circle A, the cone will be completed.

To find the development, or the covering surface, of part of a cone (Fig. 54). Let A B C D be the portion of the cone to be covered; the sides A B C D being produced to E to complete the cone. Divide the base A D into two equal parts in point F, and draw F E at right angles to A D. With radius F A from F describe a semi-circle, A 6 D. Divide this into any number of equal parts, as twelve. From E as a centre, with E A as a radius, describe an arc A G, and with E B, another arc B H, and set off from A on the arc A G the same number of equal parts as A 6 D is divided into, the last of these terminating at 12. From E, through each of these points, draw lines as in the drawing, and also from the points in A 6 D, obtained by drawing the ordinates, as 5 I parallel to 6 F E. Then the part A 12 H B is the "stretch-out" required, which, when cut out, will be found to cover the surface A B C D, part of the cone. This covering may be supposed to be made up of a number of boards, as shown by the crossed lined parts at 12, or a sheet of metal.

To develope the surface or find the "stretch-

out " for part of a cone's surface as in Fig. 55: Let *a b c d* be the parts of the cone to be covered, and the sides, *a b*, *d c*, produced to *e* to

FIG. 55.



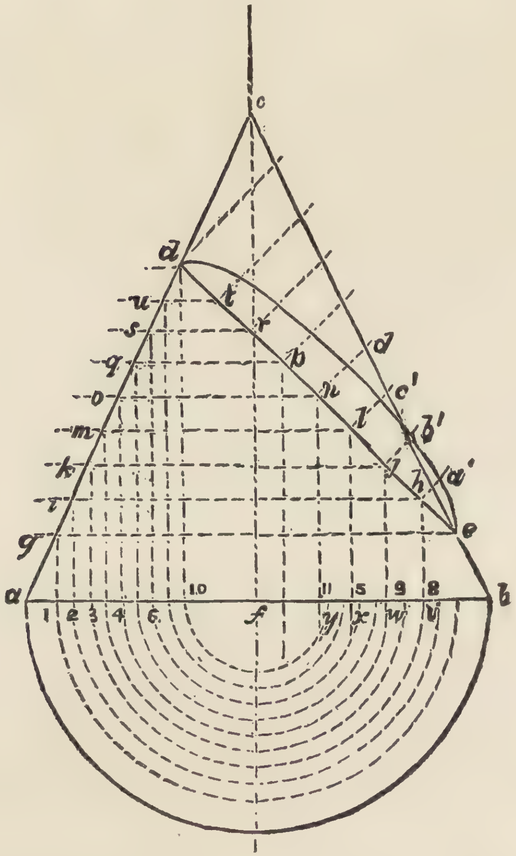
complete the cone. Divide *a d* in the point *f* into two equal parts, and from *f*, with *f a*, describe the semi-circle *a* 6 *d*. Divide this by any number of equal parts, say twelve, and from these points, on *a* 6 *d*, draw ordinates cutting the base line, *a d*, of the cone in the

points, as h f, etc., etc. From these points draw lines to the apex or vertex of the cone cutting the line b c in the points i k m, etc. From these, at right angles to c b, draw lines, as k l, i p, m n, etc. From the point e, with radius e a, describe the arc a g, and from a set off towards g the same number of equal parts as the semi-circle, a 6 d, is divided into, terminating in the point 12. From the points on the arc, a 12, draw lines to the point e. Then from 12 in a g measure to the point p, making 12 p equal to c o, the first of the perpendicular lines drawn from the points on the line c b; in like manner set off from the points 11, 10 and 9, on a g, the distances obtained from the line b c; thus the distance 7 t is equal to m n, the distance 5 s equal to i h, and 4 r to k l, and so on. Then through the points thus obtained, as p t s r, draw a curve by hand, and the part a 12 p b will be the "stretch-out," which when cut out will cover the part of the cone, a b c d. The "stretch-out" may be considered as made up of a number of pieces, as 12 p, 11 u, 10 v.

It is sometimes necessary to find the section which a cone transected or cut at any particular angle will present. For this purpose proceed as follows: To find the section of a cone cut by a line oblique to its base (Fig. 56). Let a b c be the given cone, and d e the cutting

line. Divide the base line a b into two equal parts at the point f, and draw f c perpendicu-

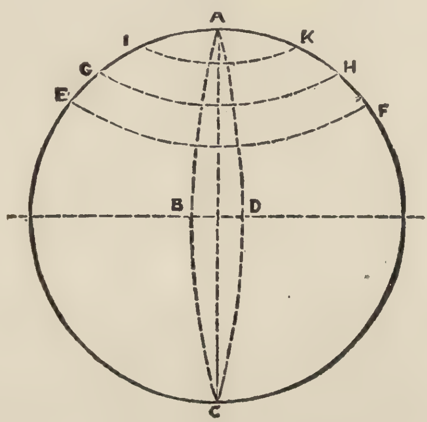
Fig. 56.



lar to the base line a b. Draw any number of lines parallel to the base a b, as e g, h i, j k,

and so on. From the points where these intersect the side *d c* of the cone, as *g e*, *i k*, etc., drop perpendicular lines, cutting *a f* in the points 1, 2, 3, 4, etc., and from the points *n l*, *j h*, other perpendicular lines as in the diagram. From *f* as a centre, with *f* 1 as a radius, describe the semi-circle 1, 7; with *f* 3 as a radius, the semi-circle 3, 8; with *f* 4, the semi-circle 4, 9; with *f* 5, the semi-circle 6, 5, and with

Fig. 57.



f 10, 10, 11. Then from the point *v*, where the semi-circle 3, 8, cuts the line dropped from *h*, measure to 8, and set off this distance *v* 8 on a line *h a′*, drawn at right angles to the cutting line *e d*, the distance *h a′* equal to *v* 8. Next from the point *n*, where the circle 4, 9 cuts the perpendicular 9 *j*, measure to 9, and set off

this distance from j to b' on the line $j\ b'$, at right angles to $d\ e$. In like manner set off the distance, x 5, from l to c', and y 11 from n to d'; a curve drawn by hand, or carried through the points $d'\ c'\ b'\ a'$, will give one-fourth of the ellipse, and the remainder of the ellipse will be found as described in connection with Fig. 52.

The solid whose development we will next briefly consider is the sphere, Fig. 57. The sphere itself does not, perhaps, enter very largely into the province of the sheet-metal worker, although it has occasionally to be constructed; but other solids (such, for instance, as the hemisphere, (Fig. 58) derived from it, are largely employed both in engineering and in architecture; as, for example, in the former, the hemispherical ends of boilers, etc., and in the latter, cupolas, domes, pendentives, niches, etc.

Fig. 58.

A sphere is a solid, the boundary of which is a curve, every point of which is situated at the same distance from the centre, the latter being the generating point of the sphere. It is not possible to develop a spherical surface with accurate exactness, and we

must be satisfied with arriving at an approximation, which, however, mostly answers all practical purposes. In order to obtain this it is usual to conceive of the outside or boundary surface of the sphere as divided into a number of parts, which form a series of polygonal sides of solids, the surfaces of these polygonal portions of the "stretch-out" terminating at common points at the vertices of the sphere.

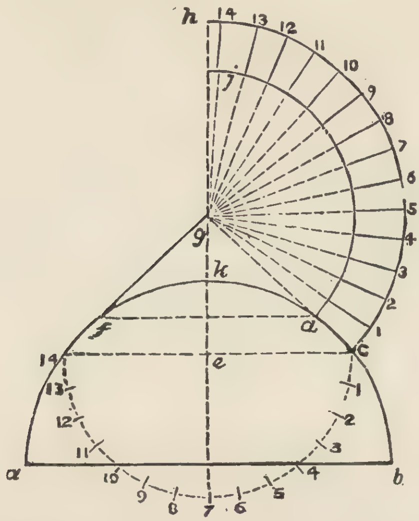
Two methods of arriving at the shape of these segmental portions of the covering of a sphere are in use. The most common is to divide the surfaces into such parts as are indicated by the lines A, B, C, D (Fig. 57), which are usually termed "gores." If we look at an ordinary terrestrial globe or a map of the world we shall find that the meridian lines or lines of latitude, which are shown as equidistant at the equator and meeting in points at the poles, divide the surface of the globe into a series of "gores." The other plan in use in the development of spherical surfaces is to consider the sphere or hemisphere, or any segment of the sphere, as made up of a series of conical rings as at E, F, G, H, and G, H, I, K (Fig. 57), the "stretch-out" of which gives a series of curved slips.

It may be observed that these latter lines correspond with those of longitude on a terres-

trial globe, and that this principle of development is the one adopted in the next example given.

To develop the covering of a hemisphere, as in Fig. 59, let *a b* be the hemisphere, and the part to be covered in depth equal to *c d*. This is assumed to be the side of the portion of a

Fig. 59.



cone, of which *c d f* 14 is the elevation, and the sides produced to complete the cone. Draw the line *c d* as to represent the base of the part of the cone, and divide it in the point *e*, and draw through *e* the line *g e* 7, at right angles from the base, *a b*, of the hemisphere.

From the point *e*, with *c e* as radius, describe the semi-circle *c* 7, 14. Divide this into any number of equal parts, as 14 in the drawing. From *g*, the apex of the cone, as centre, with *g c*, *g d* as radii, describe the arcs, *c h*, *d i*, and set off in the arc *c h* the same number of equal parts as are in 14, 7 *c* towards *h*. Through the last of these, as 14, draw 14 *g*, and through all the other parts similar lines converging to *g*; *j d* is the covering of the part, *c d f* 14. The whole surface of the hemisphere may be covered by a series of such parts, the quadrant being divided into equal parts, to give an equal depth to the covering surfaces.

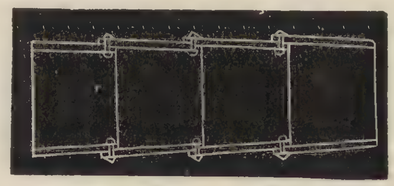
APPENDIX.

RULES FOR BOILER-MAKING, ETC.

TEMPLATE MAKING.

REMARKS.—Boilers, when made of a cylindrical form, usually consist of a series of conic frustums inserted into each other, and riveted together; the height of each frustum being the breadth of plate of iron, and the inside diameter at large end equal to the given diameter of the boiler, that of the small end twice the thickness of plate less than the large end. This will be clearly understood on inspection of figure 60.

FIG. 60.

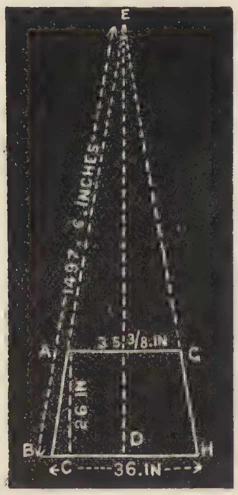


In preparing to make such a boiler, the PLATER generally procures a template or pattern plate, the length of which is some known proportion of the circumference of the boiler, and breadth suitable to

the plates of iron of which the boiler is to be made; this template is usually a thin sheet of iron or frame of wood, made to the proper length and shape and pierced with holes for the rivets, so that it forms a complete pattern by which the whole of the plates can be at once drawn and punched. The method of making the template will be easily understood by the following—

EXAMPLE.—*Let it be required to build a tubular boiler of* 36 *in., inside diameter, to be formed of* 2 *plates in the circle, the breadth of the plates* 26 *inches, and the thickness of plates* $\frac{5}{16}$ *of an inch, the distance between centres of rivet holes about* 2 *inches.*

FIG. 61.



By the above example, it is clear the frustum of one of the cones composing the boiler will be according to figure 61, as A B G H.

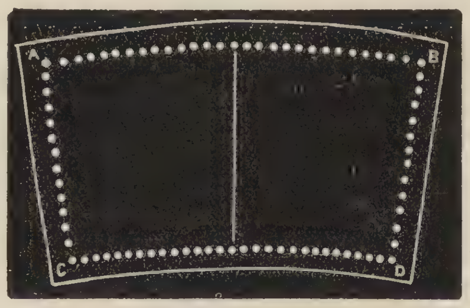
The first step will be to find the point or vertex of the cone E, of which the frustum is a part; this will be found by the following proportion, which is derived from the sixth book of Euclid, viz.: BC : BD :: BA : BE, or in words the thickness of the boiler plate is to the radius of the boiler, as the breadth of the plate is to the slant edge of the cone, which will be the radius with which the curve of the outside of the template must be drawn. The calculation is given at length.

As $\frac{5}{16}$ in. : 18 :: 26 in. : slant edge of cone$=1497 \cdot 6$.

$$\begin{array}{r} 26 \\ 18 \\ \hline 468 \\ 16 \\ \hline 5)\ 7488 \\ \hline 1497 \cdot 6 \text{ inches.} \end{array}$$

To 36 inches, the inside diameter of boiler, add $\frac{5}{16}$ of an inch, the thickness of plate, equal to $36\frac{5}{16}$ inches, the circumference of which is 114·0793 inches, and as it is proposed to have 2 plates in the circle, the length of each plate will be 57·0396 inches, on the outer curve line. And as the diameter of small end of the frustum is twice the thickness of the plate less than the larger, or $35\frac{3}{8}$ inches, to which add thickness of plate, equal to $35\frac{11}{16}$ inches, the circumference of which is 112·1158 inches; the length of plate on the inner curve line will be $\frac{112 \cdot 1158}{2} =$ 56·0579 inches, the template therefore, will be as figure 62.

Fig. 62.



A B$=57 \cdot 0396$ inches, C D$=56 \cdot 0579$ inches, A C$=$ 26 inches.

It will be perceived that as the radius with which the outside of template is to be drawn, is 1497·6 inches, it would be inconvenient to draw a circle with a radius of that length by the common mode; therefore some other method has to be adopted for finding the curve; the one usually taken is to calculate the versed line (versed sine) corresponding to the curve of the template, and then trace the curve by means of a thin lath bent round the three points, viz.:—the two extremities of the straight line and the versed line.

FIG. 63.

The mode of calculating the versed line will be easily understood by the following process, which is given at length; but let it be observed in calculating the versed line, it is only necessary to take the circumference of the given diameter, hence the circumference of 36 inches is equal to 113·0976 inches, this divided by 2 gives 56·5488 inches, for one of the plates.

In the right angled triangle E B G, is given E B $=1497{\cdot}6$ in., B G$=\frac{56{\cdot}5488}{2}=28{\cdot}2744$ inches. Then $EB^2—BG^2$ is$=EG^2$; hence EG^2 can be found, and consequently the versed line.

```
28·2744 inches.
28·2744
-----------
  1130976
 1130976
1979208
565488
2261952
565488
-----------
799·44169536=B G²
```

```
1497·6 inches.
1497·6
-----------
  89856
 104832
134784
59904
14976
-----------
2242805·76=E B²
```

```
2242805·76=E B²
    799·44—B G²
---------------
2242006·32 | 1497·33=E G.
1
------
24) 124
     96
--------
289) 2820
     2601
---------
2987) 21906
      20909
-----------
29943) 99732
       89829
------------
299463) 990300
        898389
--------------
         91911 rem.
```

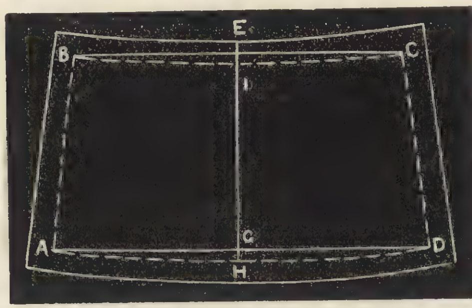
And 1497·60
1497·33

·27 = G H, the versed line, equal to $\frac{17}{64}$.

If we now take the thin plate of which the template is to be made, and draw upon it a straight line, as AD = to 57 inches, which bisect by the line EH,

and set off GH = $\frac{17}{64}$ths of an inch, the versed line; then by bending a thin rod or lath round the three

FIG. 64.



points, A H D, the curve of the outside of template may be drawn; the inside line may be drawn in a similar manner by marking off E B, E C, each equal 28 inches, half the length of the inside, and A B, D C, and H I, equal to 26 inches, the breadth of the plate.

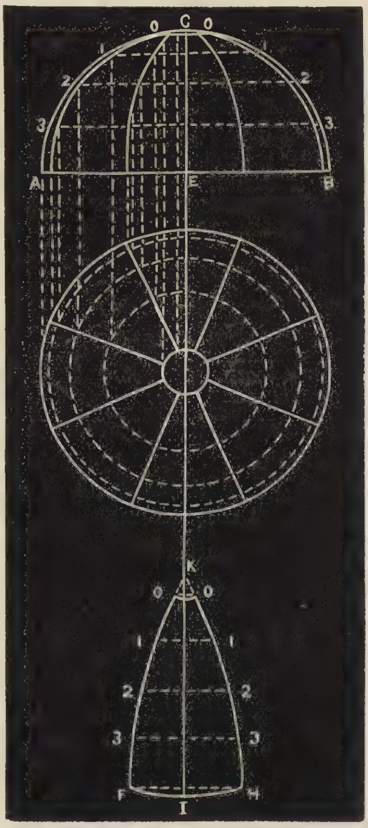
To find the breadth of the template for a given dome at any particular place, by calculation.

Suppose A B C, figure 65, to be the middle section of the dome, each plate to be a given portion of $\frac{1}{8}$ part of the whole circumference.

Bisect AB at E, and erect a perpendicular as E C; divide the arc B C into a number of equal parts, and through the points of division, 3, 2, 1, 0, draw lines parallel to A B, and since the breadth of the plate is to be $\frac{1}{8}$ of the whole circumference, it is evident that the breadth at points 3, 2, 1, 0, will also be $\frac{1}{8}$ of the circumference at these points; you have there-

fore only to measure the diameter at those points, and proceed accordingly.

Fig. 65.



Plan Fig. 66.

Fig. 67.

Thus, suppose A B, figure 65, to equal 6 feet diameter, you will find that 3 3, is by measurement, 5 feet $7\frac{5}{8}$ inches; and 2 2, is by measurement 4 feet

$7\frac{1}{8}$ inches; and 1 1, is by measurement 2 feet $11\frac{3}{4}$ inches; and 0 0, is by measurement 1 foot.

Then the circumference at A B, figure 65, will equal 18 feet $10\frac{1}{8}$ inches, divided by 8 gives 2 feet $4\frac{1}{4}$ inches for breadth of template at F H, figure 67.

The circumference at 3 3, figure 65, will be 17 feet $8\frac{3}{4}$ inches, divided by 8 gives 2 feet $2\frac{9}{16}$ inches for breadth of template at 3 3, figure 67.

The circumference at 2 2, figure 65, will be 14 feet $5\frac{1}{8}$ inches, divided by 8 gives 1 foot $9\frac{5}{8}$ inches for breadth of template at 2 2, figure 67.

The circumference at 1 1, figure 65, will be 9 feet $4\frac{1}{4}$ inches, divided by 8 gives 1 foot $2\frac{1}{32}$ inches for breadth of template at 1 1, figure 67.

The circumference at 0 0, figure 65, will be 3 feet $1\frac{5}{8}$ inches, divided by 8 gives $4\frac{11}{16}$ inches for breadth of template at 0 0, figure 67.

If you then take the thin plate of which the template is to be made, and draw upon it a straight line as F H, figure 67, and bisect it by a perpendicular I K, and set off on I K, equal distances, as 3, 2, 1, 0, same as on the dome, figure 65, and make the breadth of each point same as found by calculation, you will, upon tracing a line with a thin lath, through these points, have the shape of the template required, eight of which will make the whole dome.

Take the fourth part of the circumference of base and it will be the radius for describing the arc line of rivet holes.

N. B.—It will be seen by the plan, Fig. 66, that the plates are supposed to be jump jointed, therefore no allowance has been made for lap. Should a dome of the same description be lap jointed, an allowance must be made.

To find the template for a given Short Egg-end
SPHERICAL.

Figure 68 is supposed to represent the egg-end, the plates for forming the same are to be over-lap jointed, the breadth of each plate to bear an equal portion of the whole circumference, say $\frac{1}{6}$ part.

FIG. 68. FIG. 70.

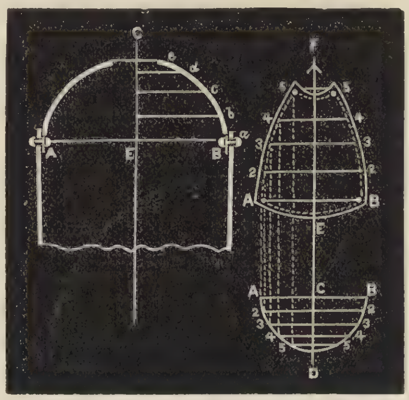


FIG. 69.

The method as laid down in the figures will be very easily understood from the following observations.

Suppose the greatest diameter of egg-end to equal 3 feet $11\frac{1}{4}$ inches, this divided by 2, gives 1 foot $11\frac{5}{8}$ inches for radius. The circumference equals 12 feet $4\frac{3}{8}$ inches, divided by 6 gives 2 feet $0\frac{3}{4}$ inch, breadth of template at the points A B, figure 70, centre to centre of rivet holes.

The radius for describing the arc line for rivet holes will be found by dividing the circumference

of the base by 4, which gives 3 feet $1\frac{3}{32}$ inches for radius.

In the first place draw a straight line as A B, figure 68, and bisect A B at E, and erect a perpendicular line E C, then with the radius of 1 foot $11\frac{5}{8}$ inches, describe the semicircle; divide the arc *a b c d e* into a number of equal parts, and through the points of division *a b c d e*, draw lines parallel to A B until they meet at perpendicular E C—this part of the operation is now complete.

The semicircle A B, figure 69, is the greatest breadth of template between centres of rivet holes; bisect the line A B at C, by a perpendicular, divide the arc A D into the same number of equal parts as taken in the arc *a b c d e*, figure 68, and draw lines parallel to A B; having done this, take the sheet iron plate for template, and draw a straight line as A B, and bisect it with a perpendicular, then set off on E F, equal distances, as *a b c d e*, figure 68, and make the breadths at each point same as AB, 2 2, 3 3, 4 4, 5 5, figure 69, drawing the lines parallel to A B; then bend a thin lath round the points, and through them trace the curve lines of both sides of the template; set the trammel points to 3 feet $1\frac{3}{32}$ inches for radius, and fix one of its points at the points A and B, the other on the perpendicular line for a centre, then describe the arc line for rivet holes; having done this, shift the sliding point of trammel until it meets at the points 5 5, keeping the same centre as before, describe the arc line for rivet holes and add the required lap round the template and it will be the shape required.

To find the template for a given long Egg-end PARABOLA; *the breadth and length of the template at any particular place.*

Let *a b c d e f*, figure 71, represent the parabola, the plates to be either over-lap or jump jointed, the

FIG. 73.

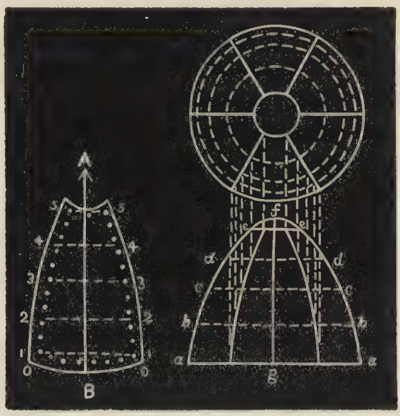


FIG. 72. FIG. 71.

breadth of each plate to be a given portion of the whole circumference, say $\frac{1}{6}$ part.

The breadth of the template at each place to be found by calculation, as follows:—

Diameter of $a\,a$ = 3 feet 6 inches; circumference of $a\,a$ = 10 feet $11\frac{7}{8}$ inches ÷ 6 = 1 foot $9\frac{15}{16}$ inches = breadth of template at points 1 1, figure 72.

Diameter of $b\,b$ = 3 feet 2 inches; circumference of $b\,b$ = 9 feet $11\frac{3}{8}$ in. ÷ 6 = 1 foot $7\frac{7}{8}$ inches = breadth of template at points 2 2.

Diameter of $c\,c$ = 2 feet 8 inches; circumference of $c\,c$ = 8 feet $4\frac{1}{2}$ in. ÷ 6 = 1 foot $4\frac{3}{4}$ inches = breadth of template at points 3 3.

Diameter of $d\,d=1$ foot 11 inches; circumference of $d\,d=6$ feet $\frac{1}{4}$ inch $\div 6=1$ foot $=$ breadth of template at points 4 4.

Diameter of $e\,e=1$ foot; circumference of $e\,e=3$ feet $1\frac{5}{8}$ inches $\div 6=6\frac{1}{4}$ inches $=$ breadth of template at points 5 5.

NOTE—The points are the centres of the rivet holes for over-lap joints.

Now take the sheet iron plate intended for the template, and draw upon it a straight line, as 11, and bisect it by a perpendicular A B, and set off on A B, equal distances as 1, 2, 3, 4, 5, same as on the *parabola*, $a\ b\ c\ d\ e$, figure 71; make the breadth at each point same as found by calculation, then by bending a thin lath round the points and tracing a line through them, will give the shape of the template required.

The radius for describing the arc line of template for rivet holes will be found by the following rule:—

RULE—To the square of the ordinate $(a\ g)$, add $\frac{4}{3}$ of the square of the abscissa $(g\ f)$, and the square root of the product will be the length of half the arc, $(a\ f\ a)$, and the same length will be the radius required.

EXAMPLE.

```
         inches.
           21 ordinate a g.
           21
          ———
           21
          42
          ———
          441 square of ordinate a g.
         1728
         ————
         2169 ( 46·5 inches=3 feet 10½ inches
         16                        [for radius.
        ————
    86)  569
         516
        ————
   925) 5300
        4625
        ════
         inches.
           36=abscissa g f.
           36
          ———
          216
         108
         ————
         1296=square of abscissa g f.
            4
         ————
     3)  5184
         ————
         1728=product of 4/3.
```

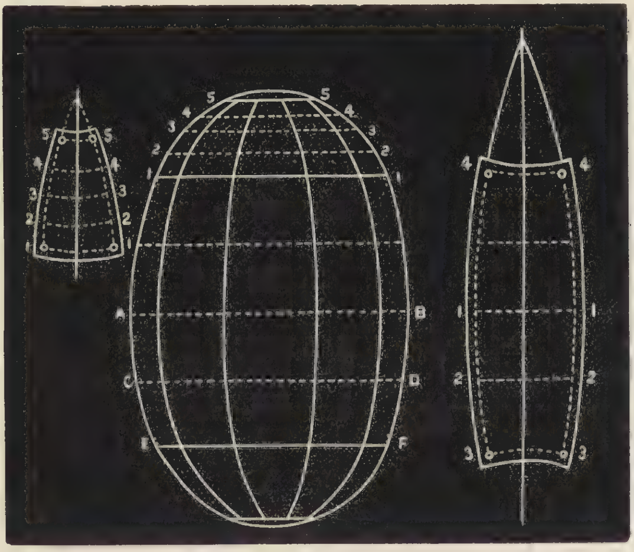
Now, having obtained the radius, set the trammel points to 3 feet $10\frac{1}{2}$ inches, and place one of its points to line 1 1, and the other on the perpendicular A for a centre, then describe the arc line for rivet holes; having done this, contract the sliding point of trammel until it meets at line 5 5, then

mark the arc line for rivet holes and place the lap round the template if required, and it will be complete as to its figure.

To find the Templates for a given Barrel SPHEROID; *the breadths and lengths at any particular place, by calculation.*

Let A B C D E F, figure 74, be one-half of the middle frustum of the barrel; the plates for forming the same are to be over-lap jointed, and the breadth

FIG. 76. FIG. 74. FIG. 75.



of each plate is to bear an equal portion of the whole circumference of each plate, say $\frac{1}{10}$ part.

Thus, the diameter of A B to measure 7 feet 6 inches, the diameter of C D to measure 7 feet 2

inches, the diameter of E F to measure 6 feet 5 inches; then the circumference of A B will equal 23 feet $6\frac{3}{4}$ inches, which, divided by 10, gives for breadth of template at 1 1 (figure 75), 2 feet $4\frac{1}{4}$ inches, at that point, between centres of rivet holes.

The circumference of C D will equal 22 feet 6 inches, divided by 10, gives for breadth of template at 2 2, 2 feet 3 inches at that point, between centres of rivet holes.

The circumference of E F will equal 20 feet $1\frac{7}{8}$ inches, divided by 10, gives 2 feet $0\frac{3}{16}$ inch for breadth of template at the point 3 3, between centres of rivet holes.

The other half of the frustum will measure the same dimensions as the above calculations.

The length of the arc and the versed sine may be found as follows:—

Suppose the cord line to measure 88 inches, this divided by 2 gives 44 inches, and the square of 44 inches equals 1936 inches.

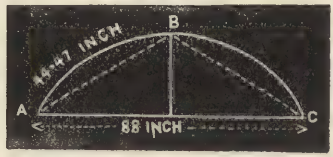
Find the versed sine by taking the difference between the two diameters A B and E F, figure 74, and divide the remainder by 2:—

Thus	A B=7	feet 6	inches.
	E F=6	" 5	"
	2) 1	1	
	0	$6\frac{1}{2}$	inches=versed sine.

Then square the versed sine and add the product to the square of $\frac{1}{2}$ the cord, and from their united sum take the square root, which gives the length of cord of half the arc A B, figure 77.

EXAMPLES.

FIG. 77.




```
        44
        44
      ----
       176
      176
     -----
      1936=square ½ of cord
        42·25
     --------
      1978·25 ( 44·47=square root.
      16
     -----
84 )  378
      336
     --------
884 )  4225
       3536
     --------
8887 )  68900
        62209
```

```
    6·5
    6·5
   ----
    325
   390
   ----
  42·25 square of
        versed sine.
```

Now if we take the square root and multiply it by 8, and from the product subtract the whole cord line, and divide the remainder by 3, we shall have the length of the arc nearly.

```
   44·47
       8
  ------
  355·76
   88
  ------
3) 267·76
  ------
   89·25=89¼ inches.
```

Consequently the length of the template, figure 75, between centres of the rivet holes 3 and 4, will be 7 feet 5¼ inches

Having completed the dimensions of template for middle frustum we proceed to find the template for the spherical or Egg ends of the barrel.

Thus, the diameter of 1 1, figure 74, will equal 6 feet $4\frac{1}{8}$ inches; the diameter of 2 2, will equal 5 feet $4\frac{1}{8}$ inches; the diameter of 3 3, will equal 4 feet $9\frac{1}{8}$ inches; the diameter of 4 4, will equal 3 feet $7\frac{1}{8}$ inches; the diameter of 5 5, will equal 2 feet $2\frac{1}{8}$ inches.

Then the circumference of 1 1, equals 19 feet $11\frac{1}{8}$ inches $\div 10$ gives for breadth of template at 1 1, figure 76, 1 foot $11\frac{29}{32}$ inches at that point, centre to centre of rivet holes.

The circumference of 2 2, equals 17 feet 10 inches, $\div 10$ gives for breadth of template at 2 2, figure 76, 1 foot $9\frac{3}{8}$ inches at that point, centre to centre of rivet holes.

The circumference of 3 3, equals 14 feet $11\frac{1}{2}$ inches, $\div 10$ gives breadth of template at 3 3, figure 76, 1 foot $5\frac{15}{16}$ inches at that point, centre to centre of rivet holes.

The circumference of 4 4, equals 11 feet $3\frac{1}{2}$ inches, $\div 10$ gives breadth of template at 4 4, figure 76, 1 foot $1\frac{1}{2}$ inch at that point, centre to centre of rivet holes.

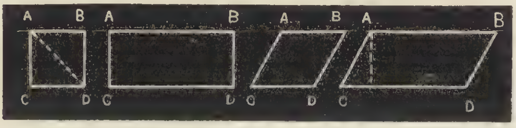
The circumference of 5 5, equals 6 feet 10 inches, $\div 10$ gives breadth of template at 5 5, figure 76, $8\frac{3}{16}$ inches at that point, centre to centre of rivet holes.

N.B. To mark out the template, follow the instructions laid down for the dome, figure 66, page 191, and the template will be the shape required.

MENSURATION OF SURFACES.

FOUR-SIDED FIGURES.

Fig. 78. Square. Fig. 79. Rectangle. Fig. 80. Rhombus. Fig. 81. Rhomboid.



To find the area of a four-sided figure, whether it be a square, a rectangle, a rhombus, or a rhomboid.

RULE—Multiply the length, A B, or C D, by the breadth or perpendicular height; the product will be the area.

EXAMPLES.

Required the superficial content of a plate of iron, measuring 2 feet 6 inches, on the side of square. Figure 78.

$$\begin{array}{r l} 2{\cdot}5 & = 2 \text{ feet 6 inches.} \\ 2\,5 & \\ \hline 125 & \\ 50 & \\ \hline 6{\cdot}25 & = 6\tfrac{1}{4} \text{ square feet.} \end{array}$$

N.B.—For the weight of a square foot of plate iron, according to its thickness—see Table II, page 224.

What is the number of superficial square feet contained in a plate of iron measuring 6 feet 9 inches long, by 3 feet 3 inches wide? Figure 79.

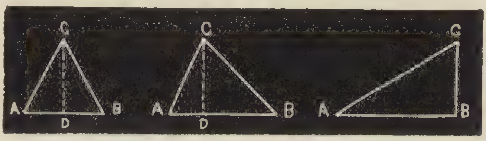
6 75=6 feet 9 inches.
3·25=3 feet 3 inches.

3375
1350
2025

21·9375=21 feet $11\frac{1}{4}$ in., or nearly 22 square feet.

TRIANGLES.

Fig. 82. Fig. 83. Fig. 84.



To find the area of a triangle, whether it be isosceles, scalene, or right-angled.

Rule—Multiply the base A B, by the perpendicular C D, and half the product will be the area.

Examples.

Required the area of a triangle, whose base is 32 inches, and perpendicular 40 inches? Figure 82.

32
40

2) 1280

640 square inches=area.

How many square feet are there in a triangle, whose base is 8 feet 3 in., and perpendicular 7 feet 6 inches? Figure 83.

```
      8·25=8 feet 3 inches.
       7·5=7 feet 6 inches.
     ------
      4125
     5775
     ------
  2) 61·875
     ------
    30·935=30 sq. ft. 11 inches, nearly.
```

Any two sides of a right-angled triangle being given, to find the third side.

Rule 1.—When the base A B, and perpendicular C B, are given, to find the hypothenuse, or longest side; to the square of the base add the square of the perpendicular, the square root of the sum will give the longest side.

Rule 2.—When the hypothenuse or longest side A C, and one side are given, to find the other side; from the square of the hypothenuse subtract the square of the given side, the square root of the remainder will be the side required.[1]

Examples.

Given the base A B, =32 inches, the perpendicular B C, =24 inches, required the length of the longest side A C. Figure 84.

```
   24       32
   24       32
  ----     ----
   96       64
  48       96
  ----     ----
  576      1024
            576
           ----
           1600 (40 in. = longest side.
           16
```

[1] The truth of these rules is evident from the 1st book of Euclid, 47 prop.

Given the base A B, 32 inches, and longest side 40 inches; required the length of the perpendicular B C. Figure 84.

32	40
32	40
64	1600
96	1024
1024	576 (24 in. = perpendicular B C.
	4
	44) 176
	176

Note—The diagonal line, or hypothenuse in a square is equal to the square root of twice the square of the side; and the side of a square is equal to the square root of half the square of its diagonal.

Examples.

Suppose each side of a square to equal 24 inches; find the diagonal.

24 in. = A B Fig. 78, page 202.
24

96
48

576
2

1152·(33.94 in. = the diagonal line from A to D.
9

63) 252
189

669) 6300
6021

6784) 27900
27136

764 rem.

The diagonal line of a square measures 34 inches; find the side of square equal thereto.

```
     34=A D, Fig. 78, page 202.
     34
    ---
    136
   102
   ----
 2)1156
   ----
    578·(24· inches=side of square.
    4
   ---
44) 178
    176
    ---
      2 rem.
```

TRAPEZOIDS AND TRAPEZIUMS.

Fig. 85.

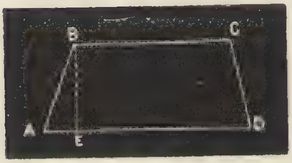
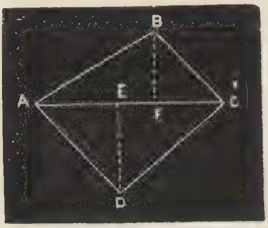


Fig. 86.



To find the area of a Trapezoid.

Rule—Add together the two parallel sides A D and B C, multiply their sum by the distance between them—B E, and half the product is the area.

To find the area of a Trapezium.

Rule—Divide the trapezium into two triangles by the diagonal line A C, and let two perpendiculars,

B F and D E, fall on the diagonal from the opposite angles; then multiply the sum of these perpendiculars by the length of the diagonal, and divide by 2, which will give the area.

EXAMPLES.

What is the area of a trapezoid whose parallel sides are 7 feet 6 in., and 9 feet 9 inches, the perpendicular distance 7 feet? Figure 85.

$$\begin{array}{rl} 7 \cdot 5 = & 7 \text{ feet } 6 \text{ inches.} \\ 9 \cdot 75 = & 9 \text{ feet } 9 \text{ inches.} \\ \hline 17 \cdot 25 & \\ 7 & \text{feet} \\ \hline 2)\ 120 \cdot 75 & \\ \hline 60 \cdot 375 = & \text{Ans.} \end{array}$$

Required the area of a trapezium A B C D, the diagonal A C 5 feet, D E 4 feet 2 inches, and B F 3 feet 4 inches. Figure 86.

$$\begin{array}{rl} \text{B F } 4 \cdot 166 = & 4 \text{ feet } 2 \text{ inches.} \\ \text{D E } 3 \cdot 333 = & 3 \text{ `` } 4 \text{ ``} \\ \hline 7 \cdot 499 & \\ 5 & \text{feet} = \text{A C} \\ \hline 2)\ 37 \cdot 495 & \\ \hline 18 \cdot 7475 = & 18\tfrac{3}{4} \text{ square feet nearly.} \end{array}$$

THE CIRCLE.

To find the circumference of a circle when the diameter is given; or the diameter when the circumference is given.

RULE 1.—Multiply the diameter by 3·1416 and the product which will be the circumference; or

divide the circumference by 3·1416 and the quotient will be the diameter.

RULE 2.—As 7 is to 22 so is the diameter to the circumference; and as 22 is to 7 so is the circumference to the diameter.

EXAMPLES.

Required the circumference of a circle when the diameter is 3 feet.

$$\begin{array}{r} 3{\cdot}1416 \\ 3 \text{ feet}=\text{diameter.} \\ \hline 9{\cdot}4248=9 \text{ feet } 5 \text{ inches.} \end{array}$$

What is the diameter of a circle when the circumference is 9·4248 feet?

$$3{\cdot}1416\ )\ 9{\cdot}4248\ (\ 3 \text{ feet diameter.}$$
$$9{\cdot}4248$$

What is the circumference of a circle when the diameter is 36 in.?

$$\begin{array}{r} \text{as } 7 : 22 :: 36 \\ 22 \\ \hline 72 \\ 72 \\ \hline 7\ )\ 792 \\ \hline 113\tfrac{1}{7} \text{ inches.}=\text{circum.} \end{array}$$

Required the diameter of a circle when the circumference is $113\frac{1}{7}$ in.

$$\begin{array}{r} \text{as } 22 : 7 :: 113\tfrac{1}{7} \text{ inches.} \\ 7 \\ \hline 22)\ 792(\ 36 \text{ in.}=\text{diameter.} \\ 66 \\ \hline 132 \\ 132 \end{array}$$

To find the area of a circle.

RULE 1.—Multiply the square of the diameter by ·7854, or the square of the circumference by ·07958; the product in either case will be the area.

RULE 2.—Multiply the circumference by the diameter, and divide the product by 4.

EXAMPLES.

Required the area of a circle, the diameter being 3 feet. By rule 1.

$$\begin{array}{r} \cdot 7854 \\ 9 = 3^2 \text{ feet.} \\ \hline 7\cdot 0686 = \text{Ans.} \end{array}$$

What is the area of a circle when the diameter is 3 feet, and circumference 9·4248 feet? By rule 2.

$$\begin{array}{r} 9\ 4248 \text{ circumference.} \\ 3 \text{ diameter.} \\ \hline 4\ )\ 28\cdot 2744 \\ \hline 7\cdot 0686 = \text{Ans.} \end{array}$$

The area of a circle given, to find the diameter or circumference.

RULE—Divide the area by ·7854, the square root of the quotient will give the diameter; then find the circumference by the common number 3·1416.

EXAMPLE.

Required to find the diameter and circumference of a circle, whose area is 452·3904 square inches.

$$\begin{array}{r} \cdot 7854\ )\ 452\cdot 3904\ (\ 576\cdot \\ 39270 \\ \hline 59690 \\ 54978 \\ \hline 47124 \\ 47124 \end{array}$$

576·) 24 inches=diameter.
4

44)176
176

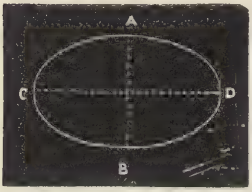
3·1416
24

125664
62832

75·3984=$7\frac{3}{8}$ inches, the circumference.

ELLIPSE OR OVAL.

Fig. 87.



To find the circumference of an ellipse or oval.

Rule—Add the length of the two axes, A B and C D together, and multiply the sum by 1·5708, the product will be the circumference; or, multiply the sum of the transverse and conjugate diameters by 3·1416, and half the product is the circumference, or near enough for most practical purposes.

Examples.

Required the length of an elliptic curve, whose conjugate A B is 40 inches and transverse C D 60 inches.

40	1·5708
60	100
100	157·0800 inches=Ans.

What is the length of the circumference, when the diameters are 30 and 40 inches?

30	3·1416
40	70
70	2) 219·9120
	109·956 inches = Ans.

To find the area of an ellipse or oval.

RULE—Multiply the transverse diameter C D, by the conjugate A B, and the product by ·7854, and the last product is the area.

EXAMPLES.

Required an area of an ellipse, whose transverse and conjugate are 20 and 10 feet.

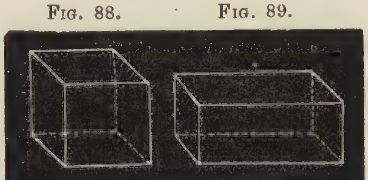
20	·7854
10	200
200	157·0800 = area.

What is the area of an ellipse, whose two axes are 14 and 12 feet?

14	·7854
12	168
168	62832
	47124
	7854
	131·9472 = area.

Mensuration of Solids.

FIG. 88. FIG. 89.



To find the superficies and solidity of a cube.

FOR SUPERFICIES.

RULE—Multiply the area of one of its sides by 6, and the product will be the area of the cube.

FOR THE SOLIDITY.

RULE—Multiply the side of the cube by itself, and that product again by the side; the last product will be the solidity of the given cube.

EXAMPLES.

Required the superficies of a cube whose side is 28 inches. Figure 88.

```
  28
  28
 ----
 224
 56
 ----
 784 area of one of the sides.
   6
 ----
4704=the superficies in square inches.
```

What is the solidity of a cube whose side is 8 feet?

```
  8
  8
 ---
 64
  8
 ---
512 solid feet=Ans.
```

To find the superficies and solidity of a parallelopipedon.

FOR SUPERFICIES.

RULE—Multiply the perimeter of the end by the length; to the product add twice the area of the end, and the sum will be the superficies.

FOR THE SOLIDITY.

RULE—Multiply the area of the end by the length, and the product will be the solidity.

EXAMPLES.

Required the superficies of a parallelopipedon whose length is 6 feet, breadth 3 feet, and thickness 2 feet. Figure 89.

$$\begin{array}{rl@{\qquad}rl}
2+2= & 4 & 3 & \\
3+3= & 6 & 2 & \\
\hline
 & 10 \text{ perimeter} & 6 & \text{area of end.} \\
 & 6 & 2 & \\
\hline
 & 60 & 12 & \text{area of both ends.} \\
 & 12 \text{ add.} & & \\
\hline
 & 72 \text{ square feet} = \text{Ans.} & &
\end{array}$$

What is the solidity of a parallelopipedon, whose length is 12 feet, breadth 6 feet, and depth 4 feet ?

$$\begin{array}{rl}
6 & \\
4 & \\
\hline
24 & \text{area of end.} \\
12 & \text{length.} \\
\hline
288 & \text{cubic feet} = \text{Ans.}
\end{array}$$

CYLINDERS AND PRISMS.

FIG. 90.

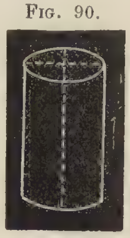
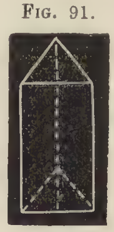


FIG. 91.



To find the solidity of cylinders and prisms.

Rule—Multiply the area of the base by the height of the cylinder or prism, and the product will give the solid content.

EXAMPLES.

Required the solid content of a cylinder whose base is three feet and height 6 feet.

$$
\begin{array}{lr l}
3\times3=9 \qquad & \cdot7854 & \\
 & 9 & \\
\hline
 & 7\cdot0686 & \text{area of base.} \\
 & 6 & \text{height of cylinder.} \\
\hline
 & 42\cdot4116 & \text{cubic feet}=\text{Ans.}
\end{array}
$$

What is the solid content of a prism, whose length is 72 inches, base 32 inches, and perpendicular height 40 inches?

$$
\begin{array}{rl}
\text{Here } 32\times40\div2=640 & \text{sq. in. the area.} \\
72 & \text{the length.} \\
\hline
1280 & \\
4480 & \\
\hline
46080 & \text{cubic in.}=\text{Ans.}
\end{array}
$$

To find the convex surface of a cylinder.

Rule—Multiply the circumference by the length of the cylinder; the product will be the convex surface required.

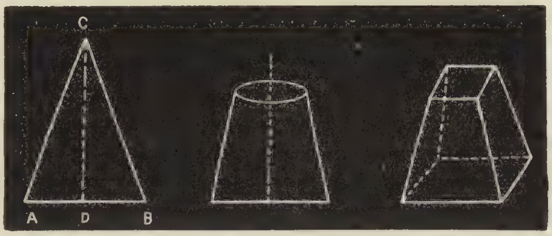
EXAMPLE.

What is the convex surface of a cylinder, whose base equals 3 feet, and perpendicular height 6 feet?

Here $3\cdot1416\times3\times6=56\cdot5488$ square feet $=$ Ans.

CONES AND PYRAMIDS.

Cone or Pyramid. Fig. 92. Frustum of a Cone. Fig. 93. Frustum of a Pyramid. Fig. 94.



To find the solidity of a cone or pyramid.

Rule—Multiply the area of the base A B, by the perpendicular height C D, and one third of the product will be the content.

Example.

What is the solidity of a cone or pyramid, whose area of base equals 1017·8784 square inches, the perpendicular height being 50 inches ?

Here $1017{\cdot}8784 \times 50 = \frac{50893{\cdot}64}{3} = \frac{16964{\cdot}92}{1728} = 9{\cdot}81$ cubic feet.

To find the solidity of the frustum of a cone.

Rule—To the product of the diameters of the two ends, add the sum of their squares; multiply this sum by the perpendicular height and by ·2618, the product will be the solid content.

Example.

What is the solidity of the frustum of a cone, whose perpendicular height is 20 inches, the greater diameter 32, and lesser 24 in. ?

$$\begin{array}{r}
\text{Here } 24\times 32= 768 \\
24^2= 576 \\
32^2=1024 \\
\hline
2368 \\
20=\text{height.} \\
\hline
47360 \\
\cdot 2618=\text{multiplier.} \\
\hline
378880 \\
47360 \\
284160 \\
94720 \\
\hline
12398\cdot 8480 \text{ cubic inches.} \\
\hline
1728=7\cdot 175 \text{ cubic feet}=\text{Ans.}
\end{array}$$

To find the solidity of the frustum of a pyramid.

RULE.—Add together the areas of the two ends of the frustum and the square root of their product, and this sum multiplied by one-third of the height will give the solidity.

EXAMPLE.

Required the solid content of the frustum of a pyramid, whose perpendicular height is 48 inches, the area of the base 288 square inches, and area of top end 128 square inches.

$$\begin{array}{r}
\text{Here } 288 \times 128 = 36864\cdot(192 = \text{sqr. root.} \\
1 \\
\hline
29)\ 268 \\
261 \\
\hline
382)\ 764 \\
764 \\
\hline
\end{array}$$

$$288 + 128 + 192 = 608$$

$$16 = \tfrac{1}{3} \text{ the height.}$$

```
       608
        16 = ⅓ the height.
      ----
      3648
      608
      ----
      9728 cubic inches = Ans.
```

To find the convex surface of a right cone or pyramid; also to find the convex surface of a frustum of a right cone or pyramid.

RULE 1.—Multiply the perimeter or circumference of the base by the slant height, or length of the side of the cone, and half the product will be the slant surface, to which add the area of the base, and the product will be the whole surface.

RULE 2.—Multiply the sum of the perimeters of the two ends by the slant height or side of the frustum, and half the product will be the slant surface; to which add the areas of the two ends, and the product will be the whole surface.

EXAMPLES.

Required the convex surface of a right cone whose diameter of base is 10 inches, and slant height 36 in.

```
     31·416
         10 in =diameter of base.
    -------
    31·4160
         36 in.=slant height.
    -------                ·7854
    1884960                 100
    942480               -------
    -------              78·5400
2) 1130.9760

    565·488 convex surface=Ans.
     78·54 area of base.

    644·028

     144=4·472 square feet the whole superficies.
```

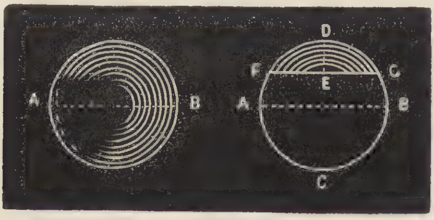
What is the convex surface of the frustum of a right cone, the diameter at the greater end being 10, at the lesser 6 inches, and slant height $15\frac{1}{3}$ inches?

$$
\begin{array}{l}
\cdot7854\times100=78\cdot54 \\
\cdot7854\times\ \ 36=28\cdot2744 \\
\hline
\qquad\qquad\ \ 106\cdot8144
\end{array}
$$

$$
\begin{array}{l}
3\cdot1416\times10=31\cdot4160 \\
3\cdot1416\times\ \ 6=18\cdot8496 \\
\hline
\qquad\qquad\ \ 50\cdot2656 \\
\qquad\qquad\qquad 15\cdot5=15\frac{1}{2}\text{ inches.} \\
\hline
\qquad\qquad\ \ 2513280 \\
\qquad\qquad 2513280 \\
\qquad\qquad 502656 \\
\hline
\qquad\quad 2)779\cdot11680 \\
\hline
\qquad\qquad 389\cdot5584\text{ convex surface}=\text{Ans.} \\
\qquad\qquad 106\cdot8144 \\
\hline
\qquad\qquad 496\cdot3728\text{ square in., the whole superficies.}
\end{array}
$$

SPHERES AND SEGMENTS OF SPHERES.

Fig. 95. Fig. 96.



To find the solid content and convex surface of a sphere or globe; also to find the solid content and convex surface of the segment of a sphere or globe.

Rule 1.—Multiply the cube of the diameter by ·5236, and the product is the solid content.

Rule 2.—Multiply the square of the diameter

A B, by 3·1416, the product will be the convex superficies.

Rule 3.—Add the square of the height, E D, to three times the square of the radius of the base F G; multiply that sum by the height and by ·5236, and the product is the solid content.

Rule 4.—Multiply the height of the segment by the whole circumference of the sphere, and the product is the convex or curved surface.

Examples

Required the solid content of a sphere whose diameter equals 12 in.

```
     12 diameter.
     12
    ———
    144
     12
   ————
   1728 cube.
  ·5236 multiplier.
  —————
  10368
  5184
 3456
8640
————————
904·7808 cubic inches=Ans.
```

Required the solid content of a spherical segment, whose height is 8 inches, and radius of the base 16 inches.

$$
\begin{array}{rl}
\text{Here } 8^2= & 64 \\
16^2\times 3= & 768 \\
\hline
 & 832 \\
 & 8 \text{ the height.} \\
\hline
 & 6656 \\
 & \cdot 5236 \text{ multiplier.} \\
\hline
 & 39936 \\
 & 19968 \\
 & 13312 \\
 & 33280 \\
\hline
 & 3485\cdot 0816 \text{ cubic inches=Ans.}
\end{array}
$$

What is the convex surface of a sphere, the diameter being 12 in. ?

$$
\begin{array}{rl}
 & 12 \text{ diameter.} \\
 & 12 \\
\hline
 & 144 \text{ square.} \\
 & 3\cdot 1416 \text{ multiplier.} \\
\hline
 & 864 \\
 & 144 \\
 & 576 \\
 & 144 \\
 & 432 \\
\hline
 & 452\cdot 3904 \text{ square inches=Ans.}
\end{array}
$$

What is the surface of a segment of a sphere, whose height is 8 in., the diameter being 50 inches ?

$$
\begin{array}{rl}
 & 3\cdot 1416 \\
 & 50 \\
\hline
 & 157\cdot 0800 \text{ the circumference.} \\
 & 8 \text{ the height.} \\
\hline
 & 1256\cdot 6400 \text{ square inches=Ans.}
\end{array}
$$

APPROXIMATE RULES

FOR FINDING THE

WEIGHT OF DIFFERENT FIGURES OF WROUGHT IRON AND STEEL.

RULE 1. *For Round Iron.*—Multiply the square of the diameter in inches, by the length in feet, and by 2·63, and the product will be the weight in pounds avoirdupois, *nearly.*

RULE 2. *For Square Iron.*—Multiply the area of the end of the bar in inches, by the length in feet, and by 3·36; the product will be the weight in pounds avoirdupois, *nearly.*

RULE 3. *For Square, Angled,* **T**, *Convex, or any figure of Beam Iron.*—Ascertain the area of the end of each figure of bar, in inches, then multiply the area by the length in feet, and that product by 10, and divide by three; the remainder will be the weight in pounds avoirdupois, *nearly.*

RULE 4. *For Square Cast Steel.*—Multiply the area of the end of the bar in inches, by the length in feet, and that product by 3·4; the product will be the weight in pounds avoirdupois, *nearly.*

RULE 5. *For Round Cast Steel.*—Multiply the square of the diameter in inches, by the length in feet, and that product by 2·67; the product will give the weight in pounds avoirdupois, *nearly.*

EXAMPLES.

What is the weight of a round bar of wrought iron, 6 feet long and 2 inches diameter?

2 inches diameter.
2
—
4 square of diameter.
6 feet, the length.
—
24·
2·63 multiplier.
——
72
144
48
——
63·12=2 qrs. 7 lbs.—*Ans.*

The area of the end of a bar of square angled iron equals 3 square inches; what is the weight of 6 feet in length?

3 square inches=area
6 feet, the length
—
18
10
——
3)180
——
60 lbs.=*Ans.*

What is the weight of a square bar of wrought iron 6 feet long and $2\frac{1}{2}$ inches on side of square?

$$
\begin{array}{r l}
2{\cdot}5 & = 2\tfrac{1}{2} \text{ inches, side of square.} \\
2{\cdot}5 & \\
\hline
125 & \\
50 & \\
\hline
6{\cdot}25 & = \text{area of end of bar.} \\
6 & \text{feet, the length.} \\
\hline
37{\cdot}50 & \\
3{\cdot}36 & \text{multiplier.} \\
\hline
22500 & \\
11250 & \\
11250 & \\
\hline
126{\cdot}0000 & = \textit{Ans.}\ 126 \text{ lbs.}
\end{array}
$$

The area of the end of a bar of convex (or half round iron) is equal to $2\frac{3}{4}$ square inches: what is the weight of 12 feet?

$$
\begin{array}{r l}
2{\cdot}75 & \text{square inches} = \text{area} \\
12 & \\
\hline
3300 & \\
10 & \\
\hline
3)330{\cdot}00 & \\
\hline
110{\cdot} & \text{lbs.} = \textit{Ans.}
\end{array}
$$

TABLE I.

WEIGHT OF WROUGHT IRON AND STEEL.

Metals	Weight of a cubic foot in ounces.	Weight of a cubic foot in pounds.	Weight of a cubic inch in parts of a pound.
Iron Bars	7,788	486·8	0·281
Steel, soft	7,833	489·6	0·283
" hardened but not tempered	7,840	490·0	0·283
" tempered but not hardened	7,816	488·5	0·283
" tempered and hardened .	7,818	488·6	0·283

TABLE II.

WEIGHT OF BOILER PLATES.

Per Square Foot.

From $\frac{1}{8}$ of an inch to $1\frac{1}{8}$ inch thick.

Thick	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$
	qrs lbs	qrs lbs	qrs lbs	qrs lbs	qrs lbs	qrs lbs	qrs lbs	qrs lbs
Weight	0 5	0 $7\frac{1}{2}$	0 10	0 $12\frac{1}{2}$	0 15	0 $17\frac{1}{2}$	0 20	0 $22\frac{1}{2}$
Thick	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1in.	$1\frac{1}{8}$in.
	qrs lbs	qrs lbs	qrs lbs	qrs lbs	qrs lbs	qrs lbs	qrs lbs	qrs lbs
Weight	0 25	0 $27\frac{1}{2}$	1 2	1 $4\frac{1}{4}$	1 7	1 $9\frac{1}{2}$	1 12	1 17

TABLE III.

Weight of Malleable Round Iron, from 1 foot to 5 feet in length.

Size of Iron in inches and parts.	1 FOOT.			2 FEET.			3 FEET.			4 FEET.			5 FEET.		
	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.
$0\frac{1}{2}$	0	0	10	0	1	4	0	1	14	0	2	8	0	3	2
$0\frac{5}{8}$	0	1	0	0	2	0	0	3	0	0	4	0	0	5	0
$0\frac{3}{4}$	0	1	7	0	2	14	0	4	5	0	5	12	0	7	3
$0\frac{7}{8}$	0	2	0	0	4	0	0	6	0	0	8	0	0	10	0
1	0	2	10	0	5	4	0	7	14	0	10	8	0	13	2
$1\frac{1}{8}$	0	3	5	0	6	10	0	9	15	0	13	4	0	16	9
$1\frac{1}{4}$	0	4	2	0	8	4	0	12	6	0	16	8	0	20	10
$1\frac{3}{8}$	0	4	15	0	9	14	0	14	13	0	19	12	0	24	11
$1\frac{1}{2}$	0	5	15	0	11	14	0	17	13	0	23	12	1	1	11
$1\frac{5}{8}$	0	6	15	0	13	14	0	20	13	0	27	12	1	6	11
$1\frac{3}{4}$	0	8	0	0	16	0	0	24	0	1	4	0	1	12	0
$1\frac{7}{8}$	0	9	4	0	18	8	0	27	12	1	9	0	1	18	4
2	0	10	8	0	21	0	1	3	8	1	14	0	1	24	8
$2\frac{1}{8}$	0	11	14	0	23	12	1	7	10	1	19	8	2	3	6
$2\frac{1}{4}$	0	13	5	0	26	10	1	11	15	1	25	4	2	10	9
$2\frac{3}{8}$	0	14	13	1	1	10	1	16	7	2	3	4	2	18	1
$2\frac{1}{2}$	0	16	7	1	4	14	1	21	5	2	9	12	2	26	3
$2\frac{5}{8}$	0	18	2	1	8	4	1	26	6	2	16	8	3	6	10
$2\frac{3}{4}$	0	19	15	1	11	14	2	3	13	2	23	12	3	15	11
$2\frac{7}{8}$	0	21	12	1	15	8	2	9	4	3	3	0	3	24	12
3	0	23	11	1	19	6	2	15	1	3	10	12	4	6	7
$3\frac{1}{4}$	0	27	13	1	27	10	2	27	7	3	27	4	4	27	1
$3\frac{1}{2}$	1	4	5	2	8	10	3	12	15	4	17	4	5	21	9
$3\frac{3}{4}$	1	9	1	2	18	2	3	27	3	5	8	4	6	17	5
4	1	14	3	3	0	6	4	14	9	6	0	12	7	14	15
$4\frac{1}{4}$	1	19	3	3	10	6	5	1	9	6	20	12	8	11	15
$4\frac{1}{2}$	1	25	6	3	22	12	5	20	2	7	17	8	9	14	14
$4\frac{3}{4}$	2	3	5	4	6	10	6	9	15	8	13	4	10	16	9
5	2	9	15	4	19	14	7	1	13	9	11	12	11	21	11
$5\frac{1}{4}$	2	16	8	5	5	0	7	21	8	10	10	0	12	26	8
$5\frac{1}{2}$	2	23	9	5	19	2	8	14	11	11	10	4	14	5	13
6	3	10	11	6	21	6	10	4	1	13	14	12	16	25	7
7	4	16	14	9	5	12	13	22	10	18	11	8	23	0	6
8	6	0	5	12	0	10	18	0	15	24	1	4	30	1	9

TABLE IV.

Weight of Malleable Square Iron, from 1 foot to 5 feet in length.

Size of Iron in inches and parts.	1 FOOT.			2 FEET.			3 FEET.			4 FEET.			5 FEET.		
	qrs.	lbs.	oz.	qrs.	lbs	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.
0½	0	0	13	0	1	10	0	2	7	0	3	4	0	4	1
0⅝	0	1	5	0	2	10	0	3	15	0	5	4	0	6	9
0¾	0	1	14	0	3	12	0	5	10	0	7	8	0	9	6
0⅞	0	2	9	0	5	2	0	7	11	0	10	4	0	12	13
1	0	3	5	0	6	10	0	9	15	0	13	4	0	16	9
1⅛	0	4	4	0	8	8	0	12	12	0	17	0	0	21	4
1¼	0	5	4	0	10	8	0	15	12	0	21	0	0	26	4
1⅜	0	6	5	0	12	10	0	18	15	0	25	4	1	3	9
1½	0	7	9	0	15	2	0	22	11	1	2	4	1	9	13
1⅝	0	8	14	0	17	12	0	26	10	1	7	8	1	16	6
1¾	0	10	4	0	20	8	1	2	12	1	13	0	1	23	4
1⅞	0	11	13	0	23	10	1	7	7	1	19	4	2	3	1
2	0	13	7	0	26	14	1	12	5	1	25	12	2	11	3
2⅛	0	15	1	1	2	2	1	17	3	2	4	4	2	19	5
2¼	0	17	0	1	6	0	1	23	0	2	12	0	3	1	0
2⅜	0	18	15	1	9	14	2	0	13	2	19	12	3	10	11
2½	0	21	0	1	14	0	2	7	0	3	0	0	3	21	0
2⅝	0	23	2	1	16	4	2	10	6	3	4	8	3	26	10
2¾	0	25	6	1	22	12	2	20	2	3	17	8	4	14	14
2⅞	0	27	12	1	27	8	2	27	4	3	27	0	4	26	12
3	1	2	4	2	4	8	3	6	12	4	9	0	5	11	4
3¼	1	7	7	2	14	14	3	22	5	5	1	12	6	9	3
3½	1	13	2	2	26	4	4	11	6	5	24	8	7	9	10
3¾	1	18	4	3	8	8	4	26	12	6	17	0	8	7	4
4	1	25	12	3	23	8	5	21	4	7	19	0	9	16	12
4¼	2	4	11	4	9	6	6	14	1	8	18	12	10	23	7
4½	2	12	0	4	24	0	7	8	0	9	20	0	12	4	0
4¾	2	19	12	5	11	8	8	3	4	10	23	0	13	14	12
5	3	0	0	6	0	0	9	0	0	12	0	0	15	0	0
5¼	3	8	9	6	17	2	9	25	11	13	6	4	16	14	13
5½	3	17	10	7	7	4	10	24	14	14	14	8	18	4	2
6	4	8	15	8	17	14	12	26	13	17	7	12	21	16	11
7	5	24	10	11	21	4	17	17	14	23	14	8	29	11	2
8	7	19	0	15	10	0	23	1	0	30	20	0	38	11	0

TABLE V.

WEIGHT OF MALLEABLE FLAT IRON.

Thick.	Breadth.	1 FOOT.			2 FEET.			3 FEET.			4 FEET.			5 FEET.		
IN.	IN.	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.
⅛	1	0	0	6½	0	0	13	0	1	3½	0	1	10	0	2	0½
	1¼	0	0	8	0	1	0	0	1	8	0	2	0	0	2	8
	1½	0	0	10	0	1	4	0	1	14	0	2	8	0	3	2
	1¾	0	0	11½	0	1	7	0	2	2½	0	2	14	0	3	9½
	2	0	0	13	0	1	10	0	2	7	0	3	4	0	4	1
	2¼	0	0	15	0	1	14	0	2	13	0	3	12	0	4	11
	2½	0	1	0¾	0	2	1½	0	3	2¼	0	4	3	0	5	3¾
	2¾	0	1	2	0	2	4	0	3	6	0	4	8	0	5	10
	3	0	1	4	0	2	8	0	3	12	0	5	0	0	6	4
	3½	0	1	7½	0	2	15	0	4	6½	0	5	14	0	7	5½
	4	0	1	10½	0	3	5	0	4	15½	0	6	10	0	8	4½
	4½	0	1	13½	0	3	11	0	5	8½	0	7	6	0	9	3½
	5	0	2	1½	0	4	3	0	6	4½	0	8	6	0	10	7½
	5½	0	2	4¾	0	4	9½	0	6	14¼	0	9	3	0	11	7¾
	6	0	2	8	0	5	0	0	7	8	0	10	0	0	12	8
	7	0	2	15	0	5	14	0	8	13	0	11	12	0	15	11
¼	1	0	0	13	0	1	10	0	2	7	0	3	4	0	4	1
	1¼	0	1	0	0	2	0	0	3	0	0	4	0	0	5	0
	1½	0	1	4	0	2	8	0	3	12	0	5	0	0	6	4
	1¾	0	1	7	0	2	14	0	4	5	0	5	12	0	7	3
	2	0	1	11¾	0	3	7½	0	5	3¼	0	6	15	0	8	10¾
	2¼	0	1	14	0	3	12	0	5	10	0	7	8	0	9	6
	2½	0	2	1½	0	4	3	0	6	4½	0	8	6	0	10	7½
	2¾	0	2	4¾	0	4	9½	0	6	14¼	0	9	3	0	11	7¾
	3	0	2	8	0	5	0	0	7	8	0	10	0	0	12	8
	3½	0	2	15	0	5	14	0	8	13	0	11	12	0	14	11
	4	0	3	5½	0	6	11	0	10	0½	0	13	6	0	16	11½
	4½	0	3	12	0	7	8	0	11	4	0	15	0	0	18	12
	5	0	4	3	0	8	6	0	12	9	0	16	12	0	20	15
	5½	0	4	9¾	0	9	3½	0	13	13¼	0	18	7	0	23	0¾
	6	0	5	0	0	10	0	0	15	0	0	20	0	0	25	0
	7	0	5	14	0	11	12	0	17	10	0	23	8	1	1	6
	8	0	6	11½	0	13	7	0	20	2½	0	26	14	1	5	9½

WEIGHT OF MALLEABLE FLAT IRON.

Thick.	Breadth.	1 FOOT.			2 FEET.			3 FEET.			4 FEET.			5 FEET.		
IN.	IN.	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.
3/8	1	0	1	4	0	2	8	0	3	12	0	5	0	0	6	4
	1¼	0	1	9	0	3	2	0	4	11	0	6	4	0	7	13
	1½	0	1	14	0	3	12	0	5	10	0	7	8	0	9	6
	1¾	0	2	3	0	4	6	0	6	9	0	8	12	0	10	15
	2	0	2	8	0	5	0	0	7	8	0	10	0	0	12	8
	2¼	0	2	13	0	5	10	0	8	7	0	11	4	0	14	1
	2½	0	3	2	0	6	4	0	9	6	0	12	8	0	15	10
	2¾	0	3	7	0	6	14	0	10	5	0	13	12	0	17	3
	3	0	3	12	0	7	8	0	11	4	0	15	10	0	18	12
	3½	0	4	6½	0	8	13	0	13	3½	0	17	10	0	22	0½
	4	0	5	0½	0	10	1	0	15	1½	0	20	2	0	25	2½
	4½	0	5	10½	0	11	5	0	16	15½	0	22	10	1	0	4½
	5	0	6	4½	0	12	9	0	18	13½	0	25	2	1	3	6½
	5½	0	6	14¾	0	13	13½	0	20	12¼	0	27	11	1	6	9¾
	6	0	7	8¾	0	15	1½	0	22	10¼	1	2	3	1	9	11¾
	7	0	8	13	0	17	10	0	26	7	1	7	4	1	16	1
½	1	0	1	10¾	0	3	5½	0	5	0¼	0	6	11	0	8	5¾
	1¼	0	2	1½	0	4	3	0	6	4½	0	8	6	0	10	7½
	1½	0	2	8	0	5	0	0	7	8	0	10	0	0	12	8
	1¾	0	2	15	0	5	14	0	8	13	0	11	12	0	14	11
	2	0	3	5½	0	6	11	0	10	0½	0	13	6	0	16	11½
	2¼	0	3	12	0	7	8	0	11	4	0	15	0	0	18	12
	2½	0	4	3	0	8	6	0	12	9	0	16	12	0	20	15
	2¾	0	4	9¾	0	9	3½	0	13	13¼	0	18	7	0	23	0¾
	3	0	5	0½	0	10	1	0	15	1½	0	20	2	0	25	2½
	3½	0	5	14	0	11	12	0	17	10	0	23	8	1	1	6
	4	0	6	11½	0	13	7	0	20	2½	0	26	14	1	5	9½
	4½	0	7	8½	0	15	1½	0	22	10½	1	2	3	1	9	11¾
	5	0	8	6	0	16	12	0	25	2	1	5	8	1	13	14
	5½	0	9	3¾	0	18	7½	0	27	11¼	1	8	15	1	18	2¾
	6	0	10	1	0	20	2	1	2	3	1	12	4	1	22	5
	7	0	11	12	0	23	8	1	7	4	1	19	0	2	2	12
	8	0	13	7	0	26	14	1	12	5	1	25	12	2	11	3

WEIGHT OF MALLEABLE FLAT IRON.

Thick.	Breadth.	1 FOOT.			2 FEET.			3 FEET.			4 FEET.			5 FEET.		
IN.	IN.	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz	qrs	lbs.	oz.
$\frac{5}{8}$	$1\frac{1}{4}$	0	2	$9\frac{3}{4}$	0	5	$3\frac{1}{2}$	0	7	$13\frac{1}{4}$	0	10	7	0	13	$0\frac{3}{4}$
	$1\frac{1}{2}$	0	3	2	0	6	4	0	9	6	0	12	8	0	15	10
	$1\frac{3}{4}$	0	3	$10\frac{1}{2}$	0	7	5	0	10	$15\frac{1}{2}$	0	14	10	0	18	$4\frac{1}{2}$
	2	0	4	3	0	8	6	0	12	9	0	16	12	0	20	15
	$2\frac{1}{4}$	0	4	$11\frac{1}{2}$	0	9	7	0	14	$2\frac{1}{2}$	0	18	14	0	23	$9\frac{1}{2}$
	$2\frac{1}{2}$	0	5	4	0	10	8	0	15	12	0	21	0	0	26	4
	$2\frac{3}{4}$	0	5	12	0	11	8	0	17	4	0	23	0	1	0	12
	3	0	6	$4\frac{3}{4}$	0	12	$9\frac{1}{2}$	0	18	$14\frac{1}{4}$	0	25	3	1	3	$7\frac{3}{4}$
	$3\frac{1}{2}$	0	7	$5\frac{1}{2}$	0	14	11	0	22	$0\frac{1}{2}$	1	1	6	1	8	$11\frac{1}{2}$
	4	0	8	6	0	16	12	0	25	2	1	5	8	1	13	14
	$4\frac{1}{2}$	0	9	7	0	18	14	1	0	5	1	9	12	1	19	3
	5	0	10	8	0	21	0	1	3	8	1	14	0	1	24	8
	$5\frac{1}{2}$	0	11	$8\frac{3}{4}$	0	23	$1\frac{1}{2}$	1	6	$10\frac{1}{4}$	1	18	3	2	1	$11\frac{3}{4}$
	6	0	12	$9\frac{1}{2}$	0	25	3	1	9	$12\frac{1}{2}$	1	22	6	2	6	$15\frac{1}{2}$
	7	0	14	11	1	1	6	1	16	1	2	2	12	2	17	7
	8	0	16	$12\frac{1}{2}$	1	5	9	1	22	$5\frac{1}{2}$	2	11	2	2	27	$14\frac{1}{2}$
$\frac{3}{4}$	$1\frac{1}{4}$	0	3	2	0	6	4	0	9	6	0	12	8	0	15	10
	$1\frac{1}{2}$	0	3	12	0	7	8	0	11	4	0	15	0	0	18	12
	$1\frac{3}{4}$	0	4	$6\frac{1}{2}$	0	8	13	0	13	$3\frac{1}{2}$	0	17	10	0	22	$0\frac{1}{2}$
	2	0	5	$0\frac{1}{2}$	0	10	1	0	15	$1\frac{1}{2}$	0	20	2	0	25	$2\frac{1}{2}$
	$2\frac{1}{4}$	0	5	$10\frac{1}{2}$	0	11	5	0	16	$15\frac{1}{2}$	0	22	10	1	0	$4\frac{1}{2}$
	$2\frac{1}{2}$	0	6	$4\frac{3}{4}$	0	12	$9\frac{1}{2}$	0	18	$14\frac{1}{4}$	0	25	3	1	3	$7\frac{3}{4}$
	$2\frac{3}{4}$	0	6	$14\frac{3}{4}$	0	13	$13\frac{1}{2}$	0	20	$12\frac{1}{4}$	0	27	11	1	6	$9\frac{3}{4}$
	3	0	7	9	0	15	2	0	22	11	1	2	4	1	9	13
	$3\frac{1}{2}$	0	8	13	0	17	10	0	26	7	1	7	4	1	16	1
	4	0	10	1	0	20	2	1	2	3	1	12	4	1	22	5
	$4\frac{1}{2}$	0	11	5	0	22	10	1	5	15	1	17	4	2	0	9
	5	0	12	9	0	25	2	1	9	11	1	22	4	2	6	13
	$5\frac{1}{2}$	0	13	$13\frac{1}{2}$	0	27	11	1	13	$8\frac{1}{2}$	1	27	6	2	13	$3\frac{1}{2}$
	6	0	15	$1\frac{3}{4}$	1	2	$3\frac{1}{4}$	1	17	$5\frac{1}{4}$	2	4	7	2	19	$8\frac{3}{4}$
	7	0	17	10	1	7	4	1	24	14	2	14	8	3	4	2
	8	0	20	$2\frac{1}{2}$	1	12	5	2	4	$7\frac{1}{2}$	2	24	10	3	16	$12\frac{1}{2}$

WEIGHT OF MALLEABLE FLAT IRON.

Thick.	Breadth.	1 FOOT.			2 FEET.			3 FEET.			4 FEET.			5 FEET.		
IN.	IN.	qrs.	lbs.	oz.	qrs.	lbs.	oz	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.
⅞	1½	0	4	6½	0	8	13	0	13	3½	0	17	10	0	22	0½
	1¾	0	5	2	0	10	4	0	15	6	0	20	8	0	25	10
	2	0	5	14	0	11	12	0	17	10	0	23	8	1	1	6
	2¼	0	6	9½	0	13	3	0	19	12½	0	26	6	1	4	15½
	2½	0	7	5½	0	14	11	0	22	0½	1	1	6	1	8	11½
	2¾	0	8	1	0	16	2	0	24	3	1	4	4	1	12	5
	3	0	8	13	0	17	10	0	26	7	1	7	4	1	16	1
	3½	0	10	4½	0	20	9	1	2	13½	1	13	2	1	23	6½
	4	0	11	12	0	23	8	1	7	4	1	19	0	2	2	12
	4½	0	13	3¾	0	26	7½	1	11	11¼	1	24	15	2	10	2¾
	5	0	14	11	1	1	6	1	16	1	2	2	12	2	17	7
	5½	0	16	2½	1	4	5	1	20	7½	2	8	10	2	24	12½
	6	0	17	10	1	7	4	1	24	14	2	14	8	3	4	2
	7	0	20	9	1	13	2	2	5	11	2	26	4	3	18	13
	8	0	23	8	1	19	0	2	14	8	3	10	0	4	5	8
	9	0	26	7	1	24	14	2	23	5	3	21	12	4	20	3
1	1½	0	5	0½	0	10	1	0	15	1½	0	20	2	0	25	2½
	1¾	0	5	13¾	0	11	11½	0	17	9¼	0	23	7	1	1	4¾
	2	0	6	11½	0	13	7	0	20	2½	0	26	14	1	5	9½
	2¼	0	7	9	0	15	2	0	22	11	1	2	4	1	9	13
	2½	0	8	6	0	16	12	0	25	2	1	5	8	1	13	14
	2¾	0	9	3½	0	18	7	0	27	10½	1	8	14	1	18	1½
	3	0	10	1	0	20	2	1	2	3	1	12	4	1	22	5
	3½	0	11	12	0	23	8	1	7	4	1	19	0	2	2	12
	4	0	13	7	0	26	14	1	12	5	1	25	12	2	11	3
	4½	0	15	2¾	1	2	5½	1	17	8¼	2	4	11	2	19	13¾
	5	0	16	12¾	1	5	9	1	22	6¼	2	11	3	2	27	15¾
	5½	0	18	7½	1	8	15	1	27	6½	2	17	14	3	8	5½
	6	0	20	2½	1	12	5	2	4	7½	2	24	10	3	16	12½
	7	0	23	8	1	19	0	2	14	8	3	10	0	4	5	8
	8	0	26	14	1	25	12	2	24	10	3	23	8	4	22	6
	9	1	2	3¾	2	4	7½	3	6	11¼	4	8	15	5	11	2¾

TABLE VI.

WEIGHT OF A SUPERFICIAL SQUARE FOOT OF PLATE OR SHEET IRON.

Thickness measured by the Birmingham Wire Gauge.

No. of the Wire Gauge.	Thickness in Parts of an Inch.	Weight in Pounds and Ounces. lbs.	oz	No. of the Wire Gauge.	Thickness in Parts of an Inch.	Weight in Pounds and Ounces. lbs.	oz.
1	$\frac{5}{16}$	12	8	16	$\frac{1}{16}$	2	8
2		12	0	17		2	$2\frac{3}{4}$
3		11	0	18		1	$12\frac{3}{4}$
4	$\frac{1}{4}$	10	0	19		1	11
5		8	12	20		1	$8\frac{1}{2}$
6		8	2	21		1	$6\frac{1}{2}$
7	$\frac{3}{16}$	7	8	22	$\frac{1}{32}$	1	4
8		6	13	23		1	2
9		6	4	24		1	0
10		5	10	25		0	$14\frac{1}{4}$
11	$\frac{1}{8}$	5	0	26		0	$12\frac{3}{4}$
12		4	6	27		0	$11\frac{1}{2}$
13		3	12	28	$\frac{1}{64}$	0	10
14		3	2	29		0	9
15		2	13	30		0	8

TABLE VII.

FOR ASCERTAINING THE WEIGHT OF MALLEABLE IRON PIPES.

12 inches long, of various thicknesses and diameters.

Thickness in Parts of an Inch.	Decimal lbs.	Thickness in Parts of an Inch.	Decimal lbs.	Thickness in Parts of an Inch.	Decimal lbs.	Thickness in Parts of an Inch.	Decimal lbs.
$\frac{1}{32}$	·104	$\frac{1}{8}$	·416	$\frac{7}{32}$	·729	$\frac{3}{8}$	1·250
$\frac{1}{16}$	·208	$\frac{5}{32}$	·520	$\frac{1}{4}$	·833	$\frac{7}{16}$	1·459
$\frac{3}{32}$	·3125	$\frac{3}{16}$	·625	$\frac{5}{16}$	1·041	$\frac{1}{2}$	1·666

RULE—Multiply the circumference of the pipe in inches, by the decimal numbers opposite the thickness required, and by the length in feet—the product will be the weight in pounds avoirdupois *nearly*.

EXAMPLE—Required the weight of a pipe 6 feet long, 12 inches in circumference, and $\frac{1}{16}$ of an inch thick:

Here .208 lbs. $\times 12 \times 6 = 14{\cdot}976$ lbs. $= 14$ lbs. $15\frac{1}{2}$ oz. *nearly*.

TABLE VIII.

WEIGHT OF ORDINARY ANGLED IRON.

Breadth in Inches and Parts.	Thickness of Root in Inches and Parts.	Thickness in Centre of Web in Inches and Parts.	1 FOOT.			2 FEET.			3 FEET.			4 FEET.			5 FEET.			6 FEET.			7 FEET.		
			qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.	qrs.	lbs.	oz.
$1\frac{1}{4}$	$\frac{3}{8}$	$\frac{3}{16}$	0	1	7	0	2	14	0	4	5	0	5	12	0	7	3	0	8	10	0	10	1
$1\frac{1}{4}$	$\frac{7}{16}$	$\frac{1}{4}$	0	1	14	0	3	12	0	5	10	0	7	8	0	9	6	0	11	4	0	13	2
$1\frac{1}{2}$	$\frac{3}{8}$	$\frac{3}{16}$	0	1	12	0	3	8	0	5	4	0	7	0	0	8	12	0	10	8	0	12	4
$1\frac{1}{2}$	$\frac{7}{16}$	$\frac{1}{4}$	0	2	6	0	4	12	0	7	2	0	9	8	0	11	14	0	14	4	0	16	10
$1\frac{3}{4}$	$\frac{7}{16}$	$\frac{1}{4}$	0	2	11	0	5	6	0	8	1	0	10	12	0	13	7	0	16	2	0	18	13
$1\frac{3}{4}$	$\frac{1}{2}$	$\frac{5}{16}$	0	3	3	0	6	6	0	9	9	0	12	12	0	15	15	0	19	2	0	22	5
2	$\frac{1}{2}$	$\frac{1}{4}$	0	3	2	0	6	4	0	9	6	0	12	8	0	15	10	0	18	12	0	21	14
2	$\frac{9}{16}$	$\frac{5}{16}$	0	3	13	0	7	10	0	11	7	0	15	4	0	19	1	0	22	14	0	26	11
$2\frac{1}{4}$	$\frac{5}{8}$	$\frac{3}{8}$	0	5	1	0	10	2	0	15	3	0	20	4	0	25	5	1	2	6	1	7	7
$2\frac{1}{4}$	$\frac{3}{4}$	$\frac{7}{16}$	0	5	13	0	11	10	0	17	7	0	23	4	1	1	1	1	6	14	1	12	11
$2\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{8}$	0	5	12	0	11	8	0	17	4	0	23	0	1	0	12	1	6	8	1	12	4
$2\frac{1}{2}$	$\frac{3}{4}$	$\frac{7}{16}$	0	6	10	0	13	4	0	19	4	0	26	8	1	5	2	1	11	2	1	18	6
$2\frac{1}{2}$	$\frac{3}{4}$	$\frac{1}{2}$	0	7	5	0	14	10	0	21	15	1	1	4	1	8	9	1	15	14	1	23	3
$2\frac{3}{4}$	$\frac{3}{4}$	$\frac{7}{16}$	0	7	6	0	14	12	0	22	2	1	1	8	1	8	14	1	16	4	1	23	10
$2\frac{3}{4}$	$\frac{3}{4}$	$\frac{1}{2}$	0	8	5	0	16	10	0	24	15	1	5	4	1	13	9	1	21	14	2	2	3
3	$\frac{5}{8}$	$\frac{7}{16}$	0	8	1	0	16	2	0	24	3	1	4	4	1	12	8	1	20	9	2	0	10
3	$\frac{7}{8}$	$\frac{1}{2}$	0	9	3	0	18	6	0	27	9	1	8	12	1	17	15	1	27	2	2	8	5

WEIGHT OF ORDINARY ANGLED IRON.

3	$\frac{7}{8}$	$\frac{5}{8}$	0	11	3	0	22	6	1	5	9	1	16	12	1	27	15	2	11	2	2	22	5
$3\frac{1}{4}$	$\frac{3}{4}$	$\frac{7}{16}$	0	8	13	0	17	10	0	26	7	1	7	4	1	16	1	1	24	14	2	5	11
$3\frac{1}{4}$	1	$\frac{5}{8}$	0	12	0	0	24	0	1	8	0	1	20	0	2	4	0	2	16	0	3	0	0
$3\frac{1}{4}$	$1\frac{1}{8}$	$\frac{3}{4}$	0	14	6	1	0	12	1	15	2	2	1	8	2	15	14	3	2	4	3	16	10
$3\frac{1}{2}$	1	$\frac{5}{8}$	0	13	4	0	26	8	1	11	12	1	25	0	2	10	4	2	23	8	3	8	12
$3\frac{1}{2}$	$1\frac{1}{8}$	$\frac{3}{4}$	0	15	10	1	3	4	1	18	14	2	6	8	2	22	2	3	9	12	3	25	6
$3\frac{3}{4}$	$\frac{3}{4}$	$\frac{1}{2}$	0	11	10	0	23	4	1	6	14	1	18	8	2	2	2	2	13	12	2	25	6
$3\frac{3}{4}$	$\frac{7}{8}$	$\frac{5}{8}$	0	14	5	1	0	10	1	14	15	2	1	4	2	15	9	3	1	14	3	16	3
4	$\frac{5}{8}$	$\frac{1}{2}$	0	12	8	0	25	0	1	9	8	1	22	0	2	6	8	2	19	0	3	3	8
4	$\frac{3}{4}$	$\frac{5}{8}$	0	15	5	1	2	10	1	17	15	2	5	4	2	20	9	3	7	14	3	23	3
4	1	$\frac{3}{4}$	0	18	2	1	8	4	1	26	6	2	16	8	3	6	10	3	24	12	4	14	14
$4\frac{1}{2}$	$\frac{5}{8}$	$\frac{1}{2}$	0	14	2	1	0	4	1	14	6	2	0	8	2	14	10	3	0	12	3	14	14
$4\frac{1}{2}$	$\frac{3}{4}$	$\frac{5}{8}$	0	17	7	1	6	14	1	24	5	2	13	12	3	3	3	3	20	10	4	10	1
$4\frac{1}{2}$	1	$\frac{3}{4}$	0	20	0	1	13	4	2	5	14	2	26	8	3	19	2	4	11	2	5	3	2
5	$\frac{5}{8}$	$\frac{3}{8}$	0	12	0	0	24	0	1	8	0	1	20	0	2	4	0	2	16	0	3	0	0
5	$\frac{3}{4}$	$\frac{1}{2}$	0	15	13	1	3	10	1	19	7	2	7	4	2	23	1	3	10	14	3	26	11
5	1	$\frac{5}{8}$	0	19	8	1	11	0	2	2	8	2	22	0	3	13	8	4	5	0	4	24	8
5	$1\frac{1}{8}$	$\frac{3}{4}$	0	23	2	1	18	4	2	13	6	3	8	8	4	3	10	4	26	12	5	21	14
$3\frac{1}{4}\times3\frac{3}{4}$	1	$\frac{5}{8}$	0	13	4	0	26	8	1	11	12	1	25	0	2	10	4	2	23	8	3	8	12
$4\times2\frac{1}{2}$	$\frac{3}{4}$	$\frac{3}{8}$	0	7	10	0	15	4	0	22	14	1	2	8	1	10	2	1	17	12	1	25	6
4×3	$\frac{7}{8}$	$\frac{7}{16}$	0	9	8	0	19	0	1	0	8	1	10	0	1	19	8	2	1	0	2	10	8
$4\frac{3}{4}\times3$	$\frac{7}{8}$	$\frac{1}{2}$	0	12	0	0	24	0	1	8	0	1	20	0	2	4	0	2	16	0	3	0	0
5×3	1	$\frac{1}{2}$	0	12	8	0	25	0	1	9	8	1	22	0	2	6	8	2	19	0	3	3	8
6×3	$\frac{3}{4}$	$\frac{7}{16}$	0	12	5	0	24	10	1	8	15	1	21	4	2	5	9	2	17	14	3	2	3
$6\times3\frac{1}{4}$	1	$\frac{1}{2}$	0	14	9	1	1	2	1	15	11	2	2	4	2	16	13	3	3	6	3	14	15

TABLES

OF THE

CIRCUMFERENCES OF CIRCLES,

TO THE

NEAREST FRACTION OF PRACTICAL MEASUREMENT,

ALSO OF

THE AREAS OF CIRCLES, IN INCHES AND DECIMAL PARTS,
LIKEWISE IN FEET AND DECIMAL PARTS,
TOGETHER WITH TABLES OF
SIZES OF TINWARE,
ETC. ETC.

RULES THAT MAY RENDER THE FOLLOWING TABLES
MORE GENERALLY USEFUL:—

1. Any of the areas in inches, multiplied by .04328, or the areas in feet multiplied by 6·232, the product is the number of imperial gallons at 1 foot in depth.

2. Any of the areas in feet, multiplied by .03704, the product equals the number of cubic yards at 1 foot in depth.

Dia. in inch.	Circum. in inch.	Area in sq. inch.	Side of = sq.	Dia in inch.	Cir. in ft. in.	Area in sq. inch.	Area in sq. ft.
1-16	-196	-0030	-0554	4 in.	1 $0\frac{1}{2}$	12-566	-0879
1-8	-392	-0122	-1107	$4\frac{1}{8}$	1 $0\frac{7}{8}$	13-364	-0935
3-16	-589	-0276	-1661	$4\frac{1}{4}$	1 $1\frac{3}{8}$	14-186	-0993
1-4	-785	-0490	-2115	$4\frac{3}{8}$	1 $1\frac{3}{4}$	15-033	-1052
5-16	-981	-0767	-2669	$4\frac{1}{2}$	1 $2\frac{1}{8}$	15-904	-1113
3-8	1-178	-1104	-3223	$4\frac{5}{8}$	1 $2\frac{1}{2}$	16-800	-1176
7-16	1-374	-1503	-3771	$4\frac{3}{4}$	1 $2\frac{7}{8}$	17-720	-1240
				$4\frac{7}{8}$	1 $3\frac{1}{4}$	18-665	-1306
1-2	1-570	-1963	-4331	5 in.	1 $3\frac{5}{8}$	19-635	-1374
9-16	1-767	-2485	-4995	$5\frac{1}{8}$	1 $4\frac{1}{8}$	20-629	-1444
5-8	1-963	-3068	-5438	$5\frac{1}{4}$	1 $4\frac{1}{2}$	21-647	-1515
11-16	2-159	-3712	-6093	$5\frac{3}{8}$	1 $4\frac{7}{8}$	22-690	-1588
3-4	2-356	-4417	-6646	$5\frac{1}{2}$	1 $5\frac{1}{4}$	23-758	-1663
13-16	2-552	-5185	-7200	$5\frac{5}{8}$	1 $5\frac{5}{8}$	24-850	-1739
7-8	2-748	-6013	-7754	$5\frac{3}{4}$	1 6	25-967	-1817
15-16	2-945	-6903	-8308	$5\frac{7}{8}$	1 $6\frac{3}{8}$	27-108	-1897
1 in.	$3\frac{1}{8}$	-7854	$\frac{7}{8}$	6 in.	1 $6\frac{3}{4}$	28-274	-1979
$1\frac{1}{8}$	$3\frac{1}{2}$	-9940	$\frac{7}{8}$ & 3-32	$6\frac{1}{8}$	1 $7\frac{1}{4}$	29-464	-2062
$1\frac{1}{4}$	$3\frac{7}{8}$	1-227	1 in.	$6\frac{1}{4}$	1 $7\frac{5}{8}$	30-679	-2147
$1\frac{3}{8}$	$4\frac{1}{4}$	1-484	1 3-16	$6\frac{3}{8}$	1 8	31-919	-2234
$1\frac{1}{2}$	$4\frac{5}{8}$	1-767	1 5-16	$6\frac{1}{2}$	1 $8\frac{3}{8}$	33-183	-2322
$1\frac{5}{8}$	$5\frac{1}{8}$	2-074	1 7-16	$6\frac{5}{8}$	1 $8\frac{3}{4}$	34-471	-2412
$1\frac{3}{4}$	$5\frac{1}{2}$	2-405	1 9-16	$6\frac{3}{4}$	1 $9\frac{1}{8}$	35-784	-2504
$1\frac{7}{8}$	$5\frac{7}{8}$	2-761	1 11-16	$6\frac{7}{8}$	1 $9\frac{1}{2}$	37-122	-2598
2 in.	$6\frac{1}{4}$	3-141	$1\frac{3}{4}$	7 in.	1 10	38-484	-2693
$2\frac{1}{8}$	$6\frac{5}{8}$	3-546	$1\frac{7}{8}$	$7\frac{1}{8}$	1 $10\frac{3}{8}$	39-871	-2791
$2\frac{1}{4}$	7	3-976	2 in.	$7\frac{1}{4}$	1 $10\frac{3}{4}$	41-282	-2889
$2\frac{3}{8}$	$7\frac{3}{8}$	4-430	2 $\frac{1}{8}$	$7\frac{3}{8}$	1 $11\frac{1}{8}$	42-718	-2990
$2\frac{1}{2}$	$7\frac{3}{4}$	4-908	2 3-16	$7\frac{1}{2}$	1 $11\frac{1}{2}$	44-178	-3092
$2\frac{5}{8}$	$8\frac{1}{4}$	5-412	2 5-16	$7\frac{5}{8}$	1 $11\frac{7}{8}$	45-663	-3196
$2\frac{3}{4}$	$8\frac{5}{8}$	5-939	2 7-16	$7\frac{3}{4}$	2 $0\frac{3}{8}$	47-173	-3299
$2\frac{7}{8}$	9	6-491	2 9-16	$7\frac{7}{8}$	2 $0\frac{3}{4}$	48-707	-3409
3 in.	$9\frac{3}{8}$	7-068	$2\frac{5}{8}$	8 in.	2 $1\frac{1}{8}$	50-265	-3518
$3\frac{1}{8}$	$9\frac{3}{4}$	7-669	$2\frac{3}{4}$	$8\frac{1}{8}$	2 $1\frac{1}{2}$	51-848	-3629
$3\frac{1}{4}$	$10\frac{1}{4}$	8-295	$2\frac{7}{8}$	$8\frac{1}{4}$	2 $1\frac{7}{8}$	53-456	-3741
$3\frac{3}{8}$	$10\frac{5}{8}$	8-946	3 in.	$8\frac{3}{8}$	2 $2\frac{1}{4}$	55-088	-3856
$3\frac{1}{2}$	11	9-621	$3\frac{1}{8}$	$8\frac{1}{2}$	2 $2\frac{5}{8}$	56-745	-3972
$3\frac{5}{8}$	$11\frac{3}{8}$	10-320	$3\frac{1}{4}$	$8\frac{5}{8}$	2 3	58-426	-4089
$3\frac{3}{4}$	$11\frac{3}{4}$	11-044	$3\frac{3}{8}$	$8\frac{3}{4}$	2 $3\frac{3}{8}$	60-132	-4209
$3\frac{7}{8}$	$12\frac{1}{8}$	11-793	3 7-16	$8\frac{7}{8}$	2 $3\frac{7}{8}$	61-862	-4330

Dia. in inch.	Cir. in ft. in.	Area in sq. inch.	Area in sq. ft.	Dia. in inch.	Cir. in ft. in.	Area in sq. inch.	Area of sq. ft.
9 in.	2 4¼	63-617	-4453	14 in.	3 7⅞	153-938	1-0775
9⅛	2 4⅝	65-396	-4577	14⅛	3 8⅜	156-699	1-0968
9¼	2 5	67-200	-4704	14¼	3 8¾	159-485	1-1193
9⅜	2 5⅜	69-029	-4832	14⅜	3 9⅛	162-295	1-1360
9½	2 5¾	70-882	-4961	14½	3 9½	165-130	1-1569
9⅝	2 6¼	72-759	-5093	14⅝	3 9⅞	167-989	1 1749
9¾	2 6⅝	74-662	-5226	14¾	3 10¼	170-873	1-1961
9⅞	2 7	76-588	-5361	14⅞	3 10¾	173-782	1-2164
10 in.	2 7⅜	78-540	-5497	15 in.	3 11⅛	176-715	1-2370
10⅛	2 7¾	80-515	-5636	15⅛	3 11½	179-672	1-2577
10¼	2 8⅛	82-516	-5776	15¼	3 11⅞	182-654	1-2785
10⅜	2 8½	84-540	-5917	15⅜	4 0¼	185-661	1-2996
10½	2 8⅞	86-590	-6061	15½	4 0⅝	188-692	1-3208
10⅝	2 9⅜	88-664	-6206	15⅝	4 1	191-748	1-3422
10¾	2 9¾	90-762	-6353	15¾	4 1½	194-828	1-3637
10⅞	2 10⅛	92-855	-6499	15⅞	4 1⅞	197-933	1-3855
11 in	2 10½	95-033	-6652	16 in.	4 2¼	201-062	1-4074
11⅛	2 10⅞	97-205	-6874	16⅛	4 2⅝	204-216	1-4295
11¼	2 11¼	99-402	-6958	16¼	4 3	207-394	1-4517
11⅜	2 11¾	101-623	-7143	16⅜	4 3⅜	210-597	1-4741
11½	3 0⅛	103-869	-7290	16½	4 3¾	213-825	1-4967
11⅝	3 0½	106-139	-7429	16⅝	4 4¼	217-077	1-5195
11¾	3 0⅞	108-434	-7590	16¾	4 4⅝	220-353	1-5424
11⅞	3 1¼	110-753	-7752	16⅞	4 5	223·654	1-5655
12 in.	3 1⅝	113-097	-7916	17 in.	4 5⅜	226-980	1-5888
12⅛	3 2	115-466	-8082	17⅛	4 5¾	230-330	1-6123
12¼	3 2½	117-859	-8250	17¼	4 6⅛	233-705	1-6359
12⅜	3 2⅞	120-276	-8419	17⅜	4 6½	237-104	1-6597
12½	3 3¼	122-718	-8590	17½	4 6⅞	240-528	1-6836
12⅝	3 3⅝	125-185	-8762	17⅝	4 7⅜	243-977	1-7078
12¾	3 4	127-676	-8937	17¾	4 7¾	247-450	1-7321
12⅞	3 4⅜	130-192	-9113	17⅞	4 8⅛	250-947	1-7566
13 in.	3 4¾	132-732	-9291	18 in.	4 8½	254-469	1-7812
13⅛	3 5¼	135-297	-9470	18⅛	4 8⅞	258-016	1-8061
13¼	3 5⅝	137-886	-9642	18¼	4 9¼	261-587	1-8311
13⅜	3 6	140-500	-9835	18⅜	4 9¾	265-182	1-8562
13½	3 6⅜	143-139	1-0019	18½	4 10⅛	268-803	1-8816
13⅝	3 6¾	145-802	1-0206	18⅝	4 10½	272-447	1-9071
13¾	3 7⅛	148-489	1-0294	18¾	4 10⅞	276-117	1-9328
13⅞	3 7½	151-201	1-0584	18⅞	4 11¼	279-811	1-9586

Dia. in inch.	Cir. in ft. in.	Area in sq. inch.	Area in sq. ft.	Dia. in ft. in.	Cir. in ft. in.	Area in sq. inch.	Area in sq. ft.
19 in.	4 11⅝	283-529	1-9847	2 0	6 3⅜	452-390	3-1418
19⅛	5 0	287-272	1-9941	2 0¼	6 4⅛	461-864	3-2075
19¼	5 0½	291-039	2-0371	2 0½	6 4⅞	471-436	3-2731
19⅜	5 0⅞	294-831	2-0637	2 0¾	6 5¾	481-106	3-3410
19½	5 1¼	298-648	2-0904	2 1	6 6½	490-875	3-4081
19⅝	5 1⅝	302-489	2-1172	2 1¼	6 7¼	500-741	3-4775
19¾	6 2	306-355	2 1443	2 1½	6 8⅛	510-706	3-5468
19⅞	5 2⅜	310-245	2-1716	2 1¾	6 8⅞	520-769	3-6101
20 in.	5 2⅞	314-160	2-1990	2 2	6 9⅝	530-930	3-6870
20⅛	5 3¼	318-099	2-2265	2 2¼	6 10½	541-189	3-7583
20¼	5 3⅝	322-063	2-2543	2 2½	6 11¼	551-547	3-8302
20⅜	5 4	326-051	2-2822	2 2¾	7 0	562-002	3-9042
20½	5 4⅜	330-064	2-3103	2 3	7 0¾	572-556	3-9761
20⅝	5 4¾	334-101	2-3386	2 3¼	7 1⅝	583-208	4-0500
20¾	5 5⅛	338-163	2-3670	2 3½	7 2⅜	593-958	4-1241
20⅞	5 5½	342-250	2-3956	2 3¾	7 3⅛	604-807	4-2000
21 in.	5 5⅞	346-361	2-4244	2 4	7 3⅞	615-753	4-2760
21⅛	5 6⅜	350-497	2-4533	2 4¼	7 4¾	626-798	4-3521
21¼	5 6¾	354-657	2-4824	2 4½	7 5½	637-941	4-4302
21⅜	5 7⅛	358-841	2-5117	2 4¾	7 6¼	649-182	4-5083
21½	5 7½	363-051	2-5412	2 5	7 7	660-521	4-5861
21⅝	5 7⅞	367-284	2-5708	2 5¼	7 7⅛	671-958	4-6665
21¾	5 8¼	371-543	2-6007	2 5½	7 8⅝	683-494	4-7467
21⅞	5 8¾	375-826	2-6306	2 5¾	7 9½	695-128	4-8274
22 in.	5 9⅛	380-133	2-6608	2 6	7 10¼	706-860	4-9081
22⅛	5 9½	384-465	2-6691	2 6¼	7 11	718-690	4-9901
22¼	5 9⅞	388-822	2-7016	2 6½	7 11¾	730-618	5-0731
22⅜	5 10¼	393-203	2-7224	2 6¾	8 0⅝	742-644	5-1573
22½	5 10⅝	397-608	2-7632	2 7	8 1⅜	754-769	5-2278
22⅝	5 11	402-038	2-7980	2 7¼	8 2⅛	766-992	5-3264
22¾	5 11½	406-493	2-8054	2 7½	8 2⅞	779-313	5-4112
22⅞	5 11⅞	410-972	2-8658	2 7¾	8 3¼	791-732	5-4982
23 in.	6 0¼	415-476	2-8903	2 8	8 4½	804-249	5-5850
23⅛	6 0⅝	420-004	2-9100	2 8¼	8 5⅜	816-865	5-6729
23¼	6 1	424-557	2-9518	2 8½	8 6⅛	829-578	5-7601
23⅜	6 1⅜	429-135	2-9937	2 8¾	8 6⅞	842-390	5-8491
23½	6 1¾	433-737	3-0129	2 9	8 7⅝	855-300	5-9398
23⅝	6 2¼	438-363	3-0261	2 9¼	8 8½	868-308	6-0291
23¾	6 2⅝	443-014	3-0722	2 9½	8 9¼	881-415	6-1201
23⅞	6 3	447-690	0-1081	2 9¾	8 10	894-619	6-2129

Dia. in ft. in.	Cir. in ft. in.	Area in sq. inch.	Area in sq. ft.	Dia. in ft. in.	Cir. in ft. in.	Area in sq. inch.	Area in sq. ft.
2 10	8 10¾	907-922	6-3051	3 8	11 6¼	1530-53	10-559
2 10¼	8 11½	921-323	6-3981	3 8¼	11 7	1537-86	10-679
2 10½	9 0⅜	934-822	6-4911	3 8½	11 7¾	1555-28	10-800
2 10¾	9 1⅛	948-419	6-5863	3 8¾	11 8½	1572-81	10-922
2 11	9 1⅞	962-115	6-6815	3 9	11 9⅜	1590-43	11-044
2 11¼	9 2¾	975-908	6-7772	3 9¼	11 10⅛	1608-15	11-167
2 11½	9 3½	989-800	6-8738	3 9½	11 10⅞	1625-97	11 291
2 11¾	9 4¼	1003-79	6-9701	3 9¾	11 11¾	1643-89	11-415
3 0	9 5	1017-87	7·0688	3 10	12 0½	1661-90	11-534
3 0¼	9 5⅞	1032-06	7-1671	3 10¼	12 1¼	1680-02	11-666
3 0½	9 6⅝	1046-35	7-2664	3 10½	12 2	1698-23	11-793
3 0¾	9 7½	1060-73	7-3662	3 10¾	12 2⅞	1716-54	11-920
3 1	9 8¼	1075-21	7-4661	3 11	12 3⅝	1734-94	12-048
3 1¼	9 9	1089-79	7-5671	3 11¼	12 4⅜	1753-45	12-176
3 1½	9 9⅞	1104-46	7-6691	3 11½	12 5¼	1772-05	12-305
3 1¾	9 10½	1119-24	7-7791	3 11¾	12 6	1790-76	12-435
3 2	9 11⅜	1134-12	7-8681	4 0	12 6¾	1809-56	12-566
3 2¼	10 0⅛	1149-09	7-9791	4 0¼	12 7½	1828-46	12-697
3 2½	10 0⅞	1164-16	8-0846	4 0½	12 8⅜	1847-45	12-829
3 2¾	10 1¾	1179-32	8-1891	4 0¾	12 9⅛	1866-55	12-962
3 3	10 2½	1194-59	8-2951	4 1	12 9⅞	1885-74	13-095
3 3¼	10 3¼	1209-95	8-4026	4 1¼	12 10¾	1905-03	13-229
3 3½	10 4	1225-42	8-5091	4 1½	12 11½	1924-42	13-364
3 3¾	10 4⅞	1240-98	8-6171	4 1¾	13 0¼	1943-91	13-499
3 4	10 5⅝	1256-64	8-7269	4 2	13 1	1963-50	13-635
3 4¼	10 6⅜	1272-39	8-8361	4 2¼	13 1⅞	1983-18	13-772
3 4½	10 7¼	1288-25	8-9462	4 2½	13 2⅝	2002-96	13-909
3 4¾	10 8	1304-20	9-0561	4 2¾	13 3⅜	2022-84	14-047
3 5	10 8¾	1320-25	9-1686	4 3	13 4¼	2042-82	14-186
3 5¼	10 9½	1336-40	9-2112	4 3¼	13 5	2062-90	14-325
3 5½	10 10⅜	1352-65	9.3936	4 3½	13 5¾	2083-07	14-465
3 5¾	10 11⅛	1369-00	9-5061	4 3¾	13 6½	2103-35	14-606
3 6	10 11⅞	1385-44	9-6212	4 4	13 7⅜	2123-72	14-748
3 6¼	11 0¾	1401-98	9-7364	4 4¼	13 8⅛	2144-19	14-890
3 6½	11 1½	1418-62	9-8518	4 4½	13 8⅞	2164-75	15-033
3 6¾	11 2¼	1435-36	9-9671	4 4¾	13 9¾	2185-42	15-176
3 7	11 3	1452-20	10.084	4 5	13 10½	2206-18	15-320
3 7¼	11 3⅞	1469-14	10.202	4 5¼	13 11¼	2227-05	15-465
3 7½	11 4⅝	1486-17	10.320	4 5½	14 0	2248-01	15-611
3 7¾	11 5⅜	1503-30	10-439	4 5¾	14 0⅞	2269 06	15-757

Dia. in ft.	in.	Cir. in ft.	in.	Area in sq. inch.	Area in sq. ft.	Dia. in ft.	in.	Cir. in ft.	in.	Area in sq. inch.	Area in sq. ft.
4	6	14	$1\frac{5}{8}$	2290 22	15-904	5	4	16	9	3216-99	22-333
4	$6\frac{1}{4}$	14	$2\frac{3}{8}$	2311-48	16-051	5	$4\frac{1}{4}$	16	$9\frac{3}{4}$	3242-17	22-515
4	$6\frac{1}{2}$	14	$3\frac{1}{4}$	2332-83	16-200	5	$4\frac{1}{2}$	16	$10\frac{5}{8}$	3267-46	22-621
4	$6\frac{3}{4}$	14	4	2354-28	16-349	5	$4\frac{3}{4}$	16	$11\frac{3}{8}$	3292-83	22-866
4	7	14	$4\frac{3}{4}$	2375-83	16-498	5	5	17	$0\frac{1}{8}$	3318-31	23-043
4	$7\frac{1}{4}$	14	$5\frac{1}{2}$	2397-48	16-649	5	$5\frac{1}{4}$	17	$0\frac{7}{8}$	3343-88	23-221
4	$7\frac{1}{2}$	14	$6\frac{3}{8}$	2419-22	16-800	5	$5\frac{1}{2}$	17	$1\frac{3}{4}$	3369-56	23-330
4	$7\frac{3}{4}$	14	$7\frac{1}{8}$	2441-07	16-951	5	$5\frac{3}{4}$	17	$2\frac{1}{2}$	3395-33	23-578
4	8	14	$7\frac{7}{8}$	2463-01	17-104	5	6	17	$3\frac{3}{8}$	3421-20	23-758
4	$8\frac{1}{4}$	14	$8\frac{5}{8}$	2485-05	17-257	5	$6\frac{1}{4}$	17	$4\frac{1}{8}$	3447-16	23-938
4	$8\frac{1}{2}$	14	$9\frac{1}{2}$	2507-19	17-411	5	$6\frac{1}{2}$	17	$4\frac{7}{8}$	3473-23	24-119
4	$8\frac{3}{4}$	14	$10\frac{1}{4}$	2529-42	17-565	5	$6\frac{3}{4}$	17	$5\frac{5}{8}$	3499-39	24-301
4	9	14	11	2551-76	17-720	5	7	17	$6\frac{1}{2}$	3525-26	24-483
4	$9\frac{1}{4}$	14	$11\frac{7}{8}$	2574-19	17-876	5	$7\frac{1}{4}$	17	$7\frac{1}{4}$	3552-01	24-666
4	$9\frac{1}{2}$	15	$0\frac{5}{8}$	2596-72	18-033	5	$7\frac{1}{2}$	17	8	3578-47	24-850
4	$9\frac{3}{4}$	15	$1\frac{3}{8}$	2619-35	18-189	5	$7\frac{3}{4}$	17	$8\frac{3}{4}$	3605-03	25-034
4	10	15	$2\frac{1}{4}$	2642-08	18-347	5	8	17	$9\frac{5}{8}$	3631-68	25-220
4	$10\frac{1}{4}$	15	$2\frac{7}{8}$	2664-91	18-506	5	$8\frac{1}{4}$	17	$10\frac{3}{8}$	3658-44	25-405
4	$10\frac{1}{2}$	15	$3\frac{3}{4}$	2687-83	18-665	5	$8\frac{1}{4}$	17	$11\frac{1}{8}$	3685-29	25-592
4	$10\frac{3}{4}$	15	$4\frac{1}{2}$	2710-85	18-825	5	$8\frac{3}{4}$	17	$11\frac{7}{8}$	3712-24	25-779
4	11	15	$5\frac{1}{4}$	2733-97	18-985	5	9	18	$0\frac{3}{4}$	3739-28	25-964
4	$11\frac{1}{4}$	15	$6\frac{1}{8}$	2757-19	19-147	5	$9\frac{1}{4}$	18	$1\frac{1}{2}$	3766-43	26-155
4	$11\frac{1}{2}$	15	$6\frac{7}{8}$	2780-51	19-309	5	$9\frac{1}{2}$	18	$2\frac{1}{4}$	3793-67	26-344
4	$11\frac{3}{4}$	15	$7\frac{3}{4}$	2803-92	19-471	5	$9\frac{3}{4}$	18	$3\frac{1}{8}$	3821-02	26-534
5	0	15	$8\frac{1}{2}$	2827-44	19-635	5	10	18	$3\frac{7}{8}$	3848-46	26-725
5	$0\frac{1}{4}$	15	$9\frac{1}{4}$	2851-05	19-798	5	$10\frac{1}{4}$	18	$4\frac{3}{8}$	3875-99	26-916
5	$0\frac{1}{2}$	15	10	2874-76	19-963	5	$10\frac{1}{2}$	18	$5\frac{1}{2}$	3903-63	27-108
5	$0\frac{3}{4}$	15	$10\frac{3}{4}$	2898-56	20-128	5	$10\frac{3}{4}$	18	$6\frac{1}{4}$	3931-36	27-301
5	1	16	$11\frac{5}{8}$	2922-47	20-294	5	11	18	7	3959-20	27-494
5	$1\frac{1}{4}$	16	$0\frac{3}{8}$	2946-47	20-461	5	$11\frac{1}{4}$	18	$7\frac{3}{4}$	3987-13	27-688
5	$1\frac{1}{2}$	16	$1\frac{1}{4}$	2970-57	20 629	5	$11\frac{1}{2}$	18	$8\frac{5}{8}$	4015-16	27-883
5	$1\frac{3}{4}$	16	$1\frac{7}{8}$	2994-77	20-797	5	$11\frac{3}{4}$	18	$9\frac{3}{8}$	4043-28	28-078
5	2	16	$2\frac{3}{4}$	3019-07	20-965	6	0	18	$10\frac{1}{8}$	4071-51	28-274
5	$2\frac{1}{4}$	16	$3\frac{1}{2}$	3043-47	21-135	6	$0\frac{1}{4}$	18	$10\frac{7}{8}$	4099-83	28-471
5	$2\frac{1}{2}$	16	$4\frac{1}{4}$	3067-96	21-305	6	$0\frac{1}{2}$	18	$11\frac{3}{4}$	4128-25	28-663
5	$2\frac{3}{4}$	16	$5\frac{1}{8}$	3092-56	21-476	6	$0\frac{3}{4}$	19	$0\frac{1}{2}$	4156-77	28-866
5	3	16	$5\frac{7}{8}$	3117-25	21-647	6	1	19	$1\frac{1}{4}$	4185-39	29-065
5	$3\frac{1}{4}$	13	$6\frac{1}{4}$	3142-04	21-819	6	$1\frac{1}{4}$	19	$2\frac{1}{8}$	4214-11	29-264
5	$3\frac{1}{2}$	16	$7\frac{1}{2}$	3166-92	21-992	6	$1\frac{1}{2}$	19	$2\frac{7}{8}$	4242-92	29-466
5	$3\frac{3}{4}$	16	$8\frac{1}{4}$	3191-91	22-106	6	$1\frac{3}{4}$	19	$3\frac{5}{8}$	4271-83	29-665

Dia. in ft.	Dia. in in.	Cir. in ft.	Cir. in in.	Area in sq. inch.	Area in sq. ft.	Dia. in ft.	Dia. in in.	Cir. in ft.	Cir. in in.	Area in sq. inch.	Area in sq. ft.
6	2	19	4½	4300-85	29-867	6	8	20	11¼	5026-26	34-906
6	2¼	19	5¼	4329-95	30-069	6	8¼	21	0⅛	5058-02	35-125
6	2½	19	6	4359-16	30-271	6	8½	21	0⅞	5089-58	35-344
6	2¾	19	6¾	4388-47	30-475	6	8¾	21	1⅝	5121-24	35-564
6	3	19	7⅝	4417-87	30-679	6	9	21	2⅜	5153-00	35-784
6	3¼	10	8⅜	4447-37	30-884	6	9¼	21	3¼	5184-86	36-006
6	3½	19	9⅛	4476-97	31-090	6	9½	21	4	5216-82	36-227
6	3¾	19	9⅞	4506-67	31-296	6	9¾	21	4¾	5248-87	36-450
6	4	19	10¾	4536-47	31-503	6	10	21	5½	5281-02	36·674
6	4¼	19	11½	4566-36	31-710	6	10¼	21	6⅜	5313-27	36-897
6	4½	20	0¼	4596-35	31-919	6	10½	21	7⅛	5345-62	37-122
6	4¾	20	1⅛	4626-44	32-114	6	10¾	21	7⅞	5378-07	37-347
6	5	20	1⅞	4656-63	32-337	6	11	21	8¾	5410-62	37-573
6	5¼	20	2⅝	4686-92	32-548	6	11¼	21	9½	5443-26	37-700
6	5½	20	3½	4717-30	32·759	6	11½	21	10¼	5476-00	38-027
6	5¾	20	4¼	4747-79	32-970	6	11¾	21	11	5508-84	38-256
6	6	20	5	4778-37	33-183						
6	6¼	20	5¾	4809-05	33-396						
6	6½	20	6½	4839-83	33-619						
6	6¾	20	7⅜	4870-70	33-824						
6	7	20	8⅛	4901-68	34-039						
6	7¼	20	8⅞	4932-75	34-255						
6	7½	20	9¾	4963-92	34-471						
6	7¾	20	10½	4995-19	34-688						

Dia. in ft. and in.	Circum. in ft. and in.	Area in ft.	Diam in ft. and in.	Circum. in ft. and in.	Area in ft.
7 0	21 $11\frac{7}{8}$	38-4846	10 0	31 5	78-5400
1	22 3	39-4060	1	31 $8\frac{1}{8}$	79-8540
2	22 $6\frac{1}{8}$	40-3388	2	31 $11\frac{1}{4}$	81-1795
3	22 $9\frac{1}{4}$	41-2825	3	32 $2\frac{3}{8}$	82-5190
4	23 $0\frac{3}{8}$	42-2367	4	32 $5\frac{1}{2}$	83-8627
5	23 $2\frac{1}{8}$	43-2022	5	32 $8\frac{5}{8}$	85-2211
6	23 $6\frac{3}{4}$	44-1787	6	32 $11\frac{3}{4}$	86-5903
7	23 11	45-1656	7	33 $2\frac{7}{8}$	87-9697
8	24 $1\frac{1}{8}$	46-1638	8	33 $6\frac{1}{8}$	89-3668
9	24 $4\frac{1}{8}$	47-1730	9	33 $9\frac{1}{4}$	90-7627
10	24 $7\frac{1}{4}$	48-1926	10	34 $0\frac{3}{8}$	92-1749
11	24 $10\frac{3}{8}$	49-2236	11	34 $3\frac{1}{2}$	93-5986
8 0	25 $1\frac{1}{2}$	50-2656	11 0	34 $6\frac{5}{8}$	95-0334
1	25 $4\frac{5}{8}$	51-6178	1	34 $9\frac{3}{4}$	96-4783
2	25 $7\frac{7}{8}$	52-3816	2	35 $0\frac{7}{8}$	97-9347
3	25 11	53-4562	3	35 $4\frac{1}{8}$	99-4021
4	26 $2\frac{1}{8}$	54-5412	4	35 $7\frac{1}{4}$	100-8797
5	26 $5\frac{1}{4}$	55-6377	5	35 $10\frac{5}{8}$	102-3689
6	26 $8\frac{3}{8}$	56-7451	6	36 $1\frac{1}{2}$	103-8601
7	26 $11\frac{1}{2}$	57-8628	7	36 $4\frac{1}{2}$	105-3794
8	27 $2\frac{3}{4}$	58-9920	8	36 $7\frac{3}{4}$	106-9013
9	27 $5\frac{3}{4}$	60-1321	9	36 $10\frac{7}{8}$	108-4342
10	27 9	61-2826	10	37 $2\frac{3}{4}$	109-9772
11	28 $0\frac{1}{8}$	62-4445	11	37 $5\frac{1}{4}$	111-5319
9 0	28 $3\frac{1}{4}$	63-6174	12 0	37 $8\frac{3}{8}$	113-0976
1	28 $6\frac{3}{8}$	64-8006	1	37 $11\frac{1}{2}$	114-6732
2	28 $9\frac{1}{2}$	65-9951	2	38 $2\frac{5}{8}$	116-2607
3	29 $0\frac{5}{8}$	67-2007	3	38 $5\frac{3}{4}$	117-8590
4	29 $3\frac{3}{4}$	68-4166	4	38 $8\frac{7}{8}$	119-4674
5	29 7	69-6440	5	39 0	121-0876
6	29 $10\frac{1}{8}$	70-8823	6	39 $3\frac{1}{4}$	122-7187
7	30 $1\frac{1}{4}$	72-1309	7	39 $6\frac{3}{8}$	124-3598
8	30 $4\frac{3}{8}$	73-3910	8	39 $9\frac{1}{2}$	126-0127
9	30 $7\frac{1}{2}$	74-6620	9	40 $0\frac{5}{8}$	127-6765
10	30 $11\frac{5}{8}$	75-9433	10	40 $3\frac{3}{4}$	129-3504
11	31 $1\frac{3}{4}$	77-2362	11	40 $6\frac{7}{8}$	131-0360

Dia. in ft. and in.	Circum. in ft. and in.	Area in ft.	Diam in ft. and in.	Circum. in ft. and in.	Area in ft.
13 0	40 10	132-7326	16 0	50 $3\frac{1}{8}$	201-0624
1	41 $1\frac{1}{8}$	134-4391	1	50 $6\frac{1}{4}$	203-1615
2	41 $4\frac{3}{8}$	136-1574	2	50 $9\frac{5}{8}$	205-2726
3	41 $7\frac{1}{2}$	137-8867	3	51 $0\frac{1}{2}$	207-3946
4	41 $10\frac{5}{8}$	139-6260	4	51 $3\frac{3}{4}$	209-5264
5	42 $1\frac{5}{8}$	141-3771	5	51 $6\frac{1}{2}$	211-6703
6	42 $4\frac{7}{8}$	143-1391	6	51 10	213-8251
7	42 8	144-9111	7	52 $1\frac{1}{8}$	215-9896
8	42 $11\frac{1}{8}$	146-6949	8	52 $4\frac{1}{4}$	218-1662
9	43 $2\frac{1}{4}$	148-4896	9	52 $7\frac{3}{8}$	220-3537
10	43 $5\frac{1}{2}$	150-2943	10	52 $10\frac{1}{2}$	222-5510
11	43 $8\frac{5}{8}$	152-1109	11	53 $1\frac{5}{8}$	224-7603
14 0	43 $11\frac{3}{4}$	153-9484	17 0	53 $4\frac{7}{8}$	226-9806
1	44 $2\frac{7}{8}$	155-7758	1	53 8	229-2105
2	44 6	157-6250	2	53 $11\frac{1}{8}$	231-4625
3	44 $9\frac{1}{8}$	159-4852	3	54 $2\frac{1}{8}$	233-7055
4	45 $0\frac{1}{4}$	161-3553	4	54 $5\frac{3}{8}$	235-9682
5	45 $3\frac{1}{2}$	163-2373	5	54 $8\frac{1}{2}$	238-2430
6	45 $6\frac{5}{8}$	165-1303	6	54 $11\frac{5}{8}$	240-5287
7	45 $9\frac{3}{4}$	167-0331	7	55 $2\frac{7}{8}$	242-8241
8	46 $0\frac{7}{8}$	168-9479	8	55 6	245-1316
9	46 4	170-8735	9	55 $9\frac{1}{8}$	247-4500
10	46 $7\frac{1}{8}$	172-8091	10	56 $0\frac{1}{4}$	249-7781
11	46 $11\frac{1}{4}$	174-7565	11	56 $3\frac{1}{2}$	252-1184
15 0	47 $1\frac{1}{2}$	176-7150	18 0	56 $6\frac{1}{2}$	254-4696
1	47 $4\frac{5}{8}$	178-6832	1	56 $9\frac{5}{8}$	256-8303
2	47 $7\frac{3}{4}$	180-6634	2	57 $0\frac{7}{8}$	259-2033
3	47 $10\frac{7}{8}$	182-6545	3	57 4	261-5872
4	48 $2\frac{1}{2}$	184-6555	4	57 $7\frac{1}{8}$	263-9807
5	48 $5\frac{1}{8}$	186-6684	5	57 $10\frac{1}{4}$	266-3864
6	48 $8\frac{1}{4}$	188-6923	6	58 $1\frac{3}{8}$	268-8031
7	48 $11\frac{3}{8}$	190-7260	7	58 $4\frac{1}{2}$	271-2293
8	49 $2\frac{5}{8}$	192-7716	8	58 $7\frac{5}{8}$	273-6678
9	49 $5\frac{3}{4}$	194-8282	9	58 $10\frac{3}{4}$	276-1171
10	49 $8\frac{7}{8}$	196-8946	10	59 2	278-5761
11	50 0	198-9730	11	59 $5\frac{1}{4}$	281-0472

Sizes of Tin-ware in form of Frustrum of a cone.

PANS.

Size.	Diam. of top.	Diam. of bot.	Height.	Size.	Diam. of top.	Diam. of bot.	Height
20 qt.	19½ in	13 in	8 in	2 qt.	9 in	6 in	3¾ in
16 "	18	11¼	6¼	3 pt.	8¼	5¾	2¾
14 "	15¼	9¼	6¼	1 "	6¼	4	2¾
10 "	14¾	11	4⅛	Pie	9	7½	1¾
6 "	12¾	9	4				

DISH KETTLES AND PAILS.

Size.	Diam. of top.	Diam. of bot.	Height.	Size.	Diam. of top.	Diam. of bot.	Height.
14 qt.	13 in	9 in	9 in	6 qt.	9¼ in	5½ in	6½ in
10 "	11½	7	8	2 "	6½	4	4

COFFEE POTS

Size.	Diam. of top.	Diam. of bot.	Height.	Size.	Diam. of top.	Diam. of bot.	Height.
1 gal.	4 in	7 in	8½ in	3 qt.	3½ in	6 in	8½ in

WASH BOWLS.

Size	Diam. of top.	Diam. of bot.	Height.
Large Wash Bowl.......	11 in.	5¾ in.	5 in
Culinder..............	11	5¾	5
Small Wash Bowl....................	9½	5½	3¾
Milk Strainer....	9½	5½	3¾

DIPPERS.

Size,	Diam, of top;	Diam, of bot,	Height.	Size,	Diam, of top;	Diam; of bot,	Height;
½ gal.	6½ in	4 in	4 in	1 pt.	4¼ in	3⅝ in	2¾ in

MEASURES.

Size.	Diam, of top ;	Diam, of bot,	Height,	Size.	Diam. of top;	Diam, of bot,	Height,
1 gal.	5½ in	6⅛ in	9¼ in	1 pt.	2⅛ in	3¾ in	4½ in
½ "	4	4⅞	8	½ "	2⅝	2⅞	3⅛
1 qt.	3½	4	5¾				

DRUGGISTS' AND LIQUOR DEALERS' MEASURES.

Size.	Diam. of top.	Diam, of bot.	Height.	Size.	Diam. of top.	Diam. of bot.	Height
5 gal.	8 in	13½ in	12⅝ in	½ gal.	3⅛ in	6⅝ in	6 in
3 "	7	11½	10⅛	1 qt.	2½	5⅛	4⅞
2 "	6	10½	8⅝	1 pt.	2	4	4
1 "	3⅝	8¾	7½	½ "	1¾	3⅝	3⅛

American Lap Weled Iron Boiler Flues, Manufactured by the READING IRON COMPANY.

Outside Diameter.	W. G. Nos.	Weight per Foot, about,	Outside Diameter,	W, G, Nos:	Weight per Foot, about
1¼ in.	16	1 lb.	3¼	11	4
1½	15	1 1-10	3½	10	4¾
1¾	14	1½	4	10	5½
2	13	2	5	9	7½
2¼	12	2½	6	8	10
2½	12	2¾	7	7	13
2¾	11	3⅛	8	6	
3	11	3½			

Table of Effects upon Bodies by Heat.

		FAHRENHEIT
Cast Iron thoroughly smelts	at	2754°
Fine Gold melts	"	1983°
Fine Silver melts	"	1850°
Copper melts	"	2160°
Brass melts	"	1900°
Zinc melts	"	740°
Lead melts	"	594°
Bismuth melts	"	476°
Tin melts	"	421°
Tin and Bismuth equal parts	melt "	283°
Tin 3 parts Bismuth 5 and Lead 2	melt "	212°

INDEX.

CATALOGUE
OF
Practical and Scientific Books
PUBLISHED BY
HENRY CAREY BAIRD & CO.
INDUSTRIAL PUBLISHERS, BOOKSELLERS AND IMPORTERS.

810 Walnut Street, Philadelphia.

☞ Any of the Books comprised in this Catalogue will be sent by mail, free of postage, to any address in the world, at the publication prices.

☞ A Descriptive Catalogue, 90 pages, 8vo., will be sent free and free of postage, to any one in any part of the world, who will furnish his address.

☞ Where not otherwise stated, all of the Books in this Catalogue are bound in muslin.

AMATEUR MECHANICS' WORKSHOP:
A treatise containing plain and concise directions for the manipulation of Wood and Metals, including Casting, Forging, Brazing, Soldering and Carpentry. By the author of the "Lathe and Its Uses." Seventh edition. Illustrated. 8vo. . . . $2.50

ANDES.—Animal Fats and Oils:
Their Practical Production, Purification and Uses; their Properties, Falsification and Examination. 62 illustrations. 8vo. .

ANDES.—Vegetable Fats and Oils:
Their Practical Preparation, Purification and Employment; their Properties, Adulteration and Examination. 94 illustrations. 8vo.

ARLOT.—A Complete Guide for Coach Painters:
Translated from the French of M. ARLOT, Coach Painter, for eleven years Foreman of Painting to M. Eherler, Coach Maker, Paris. By A. A. FESQUET, Chemist and Engineer. To which is added an Appendix, containing Information respecting the Materials and the Practice of Coach and Car Painting and Varnishing in the United States and Great Britain 12mo. . . . $1.25

ARMENGAUD, AMOROUX, AND JOHNSON.—The Practical Draughtsman's Book of Industrial Design, and Machinist's and Engineer's Drawing Companion:

Forming a Complete Course of Mechanical Engineering and Architectural Drawing. From the French of M. Armengaud the elder, Prof. of Design in the Conservatoire of Arts and Industry, Paris, and MM. Armengaud the younger, and Amoroux, Civil Engineers. Rewritten and arranged with additional matter and plates, selections from and examples of the most useful and generally employed mechanism of the day. By WILLIAM JOHNSON, Assoc. Inst. C. E. Illustrated by fifty folio steel plates, and fifty wood-cuts. A new edition, 4to, cloth. $6 00

ARMSTRONG.—The Construction and Management of Steam Boilers:

By R. ARMSTRONG, C. E. With an Appendix by ROBERT MALLET, C. E., F. R. S. Seventh Edition. Illustrated. 1 vol. 12mo. .60

ARROWSMITH.—The Paper-Hanger's Companion:

Comprising Tools, Pastes, Preparatory Work; Selection and Hanging of Wall-Papers; Distemper Painting and Cornice-Tinting; Stencil Work; Replacing Sash-Cord and Broken Window Panes; and Useful Wrinkles and Receipts, By JAMES ARROWSMITH. A New, Thoroughly Revised, and Much Enlarged Edition. Illustrated by 25 engravings, 162 pages. (1905) $1.00

ASHTON.—The Theory and Practice of the Art of Designing Fancy Cotton and Woollen Cloths from Sample:

Giving full instructions for reducing drafts, as well as the methods of spooling and making out harness for cross drafts and finding any required reed; with calculations and tables of yarn. By FREDERIC T. ASHTON, Designer, West Pittsfield, Mass. With fifty-two illustrations. One vol. folio $5.00

ASKINSON.—Perfumes and their Preparation:

A Comprehensive Treatise on Perfumery, containing Complete Directions for Making Handkerchief Perfumes, Smelling-Salts, Sachets, Fumigating Pastils; Preparations for the Care of the Skin, the Mouth, the Hair; Cosmetics, Hair Dyes, and other Toilet Articles. By G.W. ASKINSON. Translated from the German by ISIDOR FURST. Revised by CHARLES RICE. 32 Illustrations. 8vo. $3.00

BRONGNIART.—Coloring and Decoration of Ceramic Ware.

8vo. $2.50

BAIRD.—The American Cotton Spinner, and Manager's and Carder's Guide:

A Practical Treatise on Cotton Spinning; giving the Dimensions and Speed of Machinery, Draught and Twist Calculations, etc.; with notices of recent Improvements: together with Rules and Examples for making changes in the sizes and numbers of Roving and Yarn. Compiled from the papers of the late ROBERT H. BAIRD. 12mo. $1 50

BAKER.—Long-Span Railway Bridges:
Comprising Investigations of the Comparative Theoretical and Practical Advantages of the various Adopted or Proposed Type Systems of Construction; with numerous Formulæ and Tables. By B. BAKER. 12mo. $1.00

BRANNT.—A Practical Treatise on Distillation and Rectification of Alcohol:
Comprising Raw Materials; Production of Malt, Preparation of Mashes and of Yeast; Fermentation; Distillation and Rectification and Purification of Alcohol; Preparation of Alcoholic Liquors, Liqueurs, Cordials, Bitters, Fruit Essences, Vinegar, etc.; Examination of Materials for the Preparation of Malt as well as of the Malt itself; Examination of Mashes before and after Fermentation; Alcoholometry, with Numerous Comprehensive Tables; and an Appendix on the Manufacture of Compressed Yeast and the Examination of Alcohol and Alcoholic Liquors for Fusel Oil and other Impurities. By WILLIAM T. BRANNT, Editor of "The Techno-Chemical Receipt Book." Second Edition. Entirely Rewritten. Illustrated by 105 engravings. 460 pages, 8vo. (Dec., 1903) . . . $4.00

BARR.—A Practical Treatise on the Combustion of Coal:
Including descriptions of various mechanical devices for the Economic Generation of Heat by the Combustion of Fuel, whether solid, liquid or gaseous 8vo. $2.50

BARR.—A Practical Treatise on High Pressure Steam Boilers:
Including Results of Recent Experimental Tests of Boiler Materials, together with a description of Approved Safety Apparatus, Steam Pumps, Injectors and Economizers in actual use. By WM. M. BARR. 204 Illustrations. 8vo. $3.00

BAUERMAN.—A Treatise on the Metallurgy of Iron:
Containing Outlines of the History of Iron Manufacture, Methods of Assay, and Analysis of Iron Ores, Processes of Manufacture of Iron and Steel, etc., etc. By H. BAUERMAN, F. G. S., Associate of the Royal School of Mines. Fifth Edition, Revised and Enlarged. Illustrated with numerous Wood Engravings from Drawings by J. B. JORDAN. 12mo, ... $2.00

BRANNT.—The Metallic Alloys: A Practical Guide
For the Manufacture of all kinds of Alloys, Amalgams, and Solders, used by Metal-Workers: together with their Chemical and Physical Properties and their Application in the Arts and the Industries; with an Appendix on the Coloring of Alloys and the Recovery of Waste Metals. By WILLIAM T. BRANNT. 34 Engravings. A New, Revised, and Enlarged Edition. 554 pages. 8vo. . . $4.50

BEANS.—A Treatise on Railway Curves and Location of Railroads:
By E. W. BEANS, C. E. Illustrated. 12mo. Tucks. . $1.50

BELL.—Carpentry Made Easy:

Or, The Science and Art of Framing on a New and Improved System. With Specific Instructions for Building Balloon Frames, Barn Frames, Mill Frames, Warehouses, Church Spires, etc. Comprising also a System of Bridge Building, with Bills, Estimates of Cost, and valuable Tables. Illustrated by forty-four plates, comprising nearly 200 figures. By WILLIAM E. BELL, Architect and Practical Builder. 8vo. $5.00

BEMROSE.—Fret-Cutting and Perforated Carving:

With fifty-three practical illustrations. By W. BEMROSE, JR. 1 vol. quarto $2.50

BEMROSE.—Manual of Buhl-work and Marquetry:

With Practical Instructions for Learners, and ninety colored designs. By W. BEMROSE, JR. 1 vol. quarto $3.00

BEMROSE.—Manual of Wood Carving:

With Practical Illustrations for Learners of the Art, and Original and Selected Designs. By WILLIAM BEMROSE, JR. With an Introduction by LLEWELLYN JEWITT, F. S. A., etc. With 128 illustrations, 4to. $2.50

BERSCH.—Cellulose, Cellulose Products, and Rubber Substitutes:

Comprising the Preparation of Cellulose, Parchment-Cellulose, Methods of Obtaining Sugar, Alcohol and Oxalic Acid from Wood-Cellulose; Production of Nitro-Cellulose and Cellulose Esters; Manufacture of Artificial Silk, Viscose, Celluloid, Rubber Substitutes, Oil-Rubber, and Faktis. By DR. JOSEPH BERSCH. Translated by WILLIAM T. BRANNT. 41 illustrations. (1904.) $3.00

BILLINGS.—Tobacco:

Its History, Variety, Culture, Manufacture, Commerce, and Various Modes of Use. By E. R. BILLINGS. Illustrated by nearly 200 engravings. 8vo. $3.00

BIRD.—The American Practical Dyers' Companion:

Comprising a Description of the Principal Dye-Stuffs and Chemicals used in Dyeing, their Natures and Uses; Mordants and How Made; with the best American, English, French and German processes for Bleaching and Dyeing Silk, Wool, Cotton, Linen, Flannel, Felt, Dress Goods, Mixed and Hosiery Yarns, Feathers, Grass, Felt, Fur, Wool, and Straw Hats, Jute Yarn, Vegetable Ivory, Mats, Skins, Furs, Leather, etc., etc. By Wood Aniline, and other Processes, together with Remarks on Finishing Agents, and instructions in the Finishing of Fabrics, Substitutes for Indigo, Water-Proofing of Materials, Tests and Purification of Water, Manufacture of Aniline and other New Dye Wares, Harmonizing Colors, etc., etc.; embracing in all over 800 Receipts for Colors and Shades, *accompanied by* 170 *Dyed Samples of Raw Materials and Fabrics.* By F. J. BIRD, Practical Dyer, Author of "The Dyers' Hand-Book." 8vo. $7.50

BLINN.—A Practical Workshop Companion for Tin, Sheet-Iron, and Copper-plate Workers:
Containing Rules for describing various kinds of Patterns used by Tin, Sheet-Iron and Copper-plate Workers; Practical Geometry; Mensuration of Surfaces and Solids; Tables of the Weights of Metals, Lead-pipe, etc.; Tables of Areas and Circumferences of Circles; Japan, Varnishes, Lackers, Cements, Compositions, etc., etc. By LEROY J. BLINN, Master Mechanic. With One Hundred and Seventy Illustrations. 12mo. $2.50

BOOTH.—Marble Worker's Manual:
Containing Practical Information respecting Marbles in general, their Cutting, Working and Polishing; Veneering of Marble; Mosaics; Composition and Use of Artificial Marble, Stuccos, Cements, Receipts, Secrets, etc., etc. Translated from the French by M. L. BOOTH. With an Appendix concerning American Marbles. 12mo., cloth $1.50

BRANNT.—A Practical Treatise on Animal and Vegetable Fats and Oils:
Comprising both Fixed and Volatile Oils, their Physical and Chemical Properties and Uses, the Manner of Extracting and Refining them, and Practical Rules for Testing them; as well as the Manufacture of Artificial Butter and Lubricants, etc., with lists of American Patents relating to the Extraction, Rendering, Refining, Decomposing, and Bleaching of Fats and Oils. By WILLIAM T. BRANNT, Editor of the "Techno-Chemical Receipt Book." Second Edition, Revised and in a great part Rewritten. Illustrated by 302 Engravings. In Two Volumes. 1304 pp. 8vo. $10.00

BRANNT.—A Practical Treatise on the Manufacture of Soap and Candles:
Based upon the most Recent Experiences in the Practice and Science; comprising the Chemistry, Raw Materials, Machinery, and Utensils and Various Processes of Manufacture, including a great variety of formulas. Edited chiefly from the German of Dr. C. Deite, A. Engelhardt, Dr. C. Schaedler and others; with additions and lists of American Patents relating to these subjects. By WM. T. BRANNT. Illustrated by 163 engravings. 677 pages. 8vo. . . $10.00

BRANNT.—India Rubber, Gutta-Percha and Balata:
Occurrence, Geographical Distribution, and Cultivation, Obtaining and Preparing the Raw Materials, Modes of Working and Utilizing them, Including Washing, Maceration, Mixing, Vulcanizing, Rubber and Gutta-Percha Compounds, Utilization of Waste, etc. By WILLIAM T. BRANNT. Illustrated. 12mo. (1900.) . . $3.00

BRANNT—WAHL.—The Techno-Chemical Receipt Book:
Containing several thousand Receipts covering the latest, most important, and most useful discoveries in Chemical Technology, and their Practical Application in the Arts and the Industries. Edited chiefly from the German of Drs. Winckler, Elsner, Heintze, Mierzinski, Jacobsen, Koller and Heinzerling, with additions by WM. T. BRANNT and WM. H. WAHL, Ph. D. Illustrated by 78 engravings. 12mo. 495 pages. $2.00

BROWN.—Five Hundred and Seven Mechanical Movements:
Embracing all those which are most important in Dynamics, Hydraulics, Hydrostatics, Pneumatics, Steam Engines, Mill and other Gearing, Presses, Horology, and Miscellaneous Machinery; and including many movements never before published, and several of which have only recently come into use. By HENRY T. BROWN. 12mo. $1.00

BUCKMASTER.—The Elements of Mechanical Physics:
By J. C. BUCKMASTER. Illustrated with numerous engravings. 12mo. $1.00

BULLOCK.—The American Cottage Builder:
A Series of Designs, Plans and Specifications, from $200 to $20,000, for Homes for the People; together with Warming, Ventilation, Drainage, Painting and Landscape Gardening. By JOHN BULLOCK, Architect and Editor of "The Rudiments of Architecture and Building," etc., etc. Illustrated by 75 engravings. 8vo. $2.50

BULLOCK.—The Rudiments of Architecture and Building:
For the use of Architects, Builders, Draughtsmen, Machinists, Engineers and Mechanics. Edited by JOHN BULLOCK, author of "The American Cottage Builder." Illustrated by 250 Engravings. 8vo. $2.50

BURGH.—Practical Rules for the Proportions of Modern Engines and Boilers for Land and Marine Purposes.
By N. P. BURGH, Engineer. 12mo. $1.50

BYLES.—Sophisms of Free Trade and Popular Political Economy Examined.
By a BARRISTER (SIR JOHN BARNARD BYLES, Judge of Common Pleas). From the Ninth English Edition, as published by the Manchester Reciprocity Association. 12mo. $1.25

BOWMAN.—The Structure of the Wool Fibre in its Relation to the Use of Wool for Technical Purposes:
Being the substance, with additions, of Five Lectures, delivered at the request of the Council, to the members of the Bradford Technical College, and the Society of Dyers and Colorists. By F. H. BOWMAN, D. Sc., F. R. S. E., F. L. S. Illustrated by 32 engravings. 8vo. $7.50

BYRNE.—Hand-Book for the Artisan, Mechanic, and Engineer:
Comprising the Grinding and Sharpening of Cutting Tools, Abrasive Processes, Lapidary Work, Gem and Glass Engraving, Varnishing and Lackering, Apparatus, Materials and Processes for Grinding and

Polishing, etc. By OLIVER BYRNE. Illustrated by 185 wood engravings. 8vo. $5.00

BYRNE.—Pocket-Book for Railroad and Civil Engineers:
Containing New, Exact and Concise Methods for Laying out Railroad Curves, Switches, Frog Angles and Crossings; the Staking out of work; Levelling; the Calculation of Cuttings: Embankments; Earthwork, etc. By OLIVER BYRNE. 18mo., full bound, pocket-book form $1.50

BYRNE.—The Practical Metal-Worker's Assistant:
Comprising Metallurgic Chemistry; the Arts of Working all Metals and Alloys; Forging of Iron and Steel; Hardening and Tempering; Melting and Mixing; Casting and Founding; Works in Sheet Metal; the Processes Dependent on the Ductility of the Metals; Soldering; and the most Improved Processes and Tools employed by Metal-Workers. With the Application of the Art of Electro-Metallurgy to Manufacturing Processes; collected from Original Sources, and from the works of Holtzapffel, Bergeron, Leupold, Plumier, Napier, Scoffern, Clay, Fairbairn and others. By OLIVER BYRNE. A new, revised and improved edition, to which is added an Appendix, containing The Manufacture of Russian Sheet-Iron. By JOHN PERCY, M. D., F. R. S. The Manufacture of Malleable Iron Castings, and Improvements in Bessemer Steel. By A. A. FESQUET, Chemist and Engineer. With over Six Hundred Engravings, Illustrating every Branch of the Subject. 8vo. $5.00

BYRNE.—The Practical Model Calculator:
For the Engineer, Mechanic, Manufacturer of Engine Work, Naval Architect, Miner and Millwright. By OLIVER BYRNE. 8vo., nearly 600 pages . . . . (Scarce.)

CABINET MAKER'S ALBUM OF FURNITURE:
Comprising a Collection of Designs for various Styles of Furniture. Illustrated by Forty-eight Large and Beautifully Engraved Plates. Oblong, 8vo. $1.50

CALLINGHAM.—Sign Writing and Glass Embossing:
A Complete Practical Illustrated Manual of the Art. By JAMES CALLINGHAM. To which are added Numerous Alphabets and the Art of Letter Painting Made Easy. By JAMES C. BADENOCH. 258 pages. 12mo. $1.50

CAMPIN.—A Practical Treatise on Mechanical Engineering:
Comprising Metallurgy, Moulding, Casting, Forging, Tools, Workshop Machinery, Mechanical Manipulation, Manufacture of Steam-Engines, etc. With an Appendix on the Analysis of Iron and Iron Ores. By FRANCIS CAMPIN, C. E. To which are added, Observations on the Construction of Steam Boilers, and Remarks upon Furnaces used for Smoke Prevention; with a Chapter on Explosions. By R. ARMSTRONG, C. E., and JOHN BOURNE. (Scarce.)

CAREY.—A Memoir of Henry C. Carey.
By DR. WM. ELDER. With a portrait. 8vo., cloth . . 75

CAREY.—The Works of Henry C. Carey:
Harmony of Interests: Agricultural, Manufacturing and Commercial. 8vo. $1.25
Manual of Social Science. Condensed from Carey's "Principles of Social Science." By KATE MCKEAN. 1 vol. 12mo. . $2.00
Miscellaneous Works. With a Portrait. 2 vols. 8vo. $10.00
Past, Present and Future. 8vo. $2.50
Principles of Social Science. 3 volumes, 8vo. . . $7.50
The Slave-Trade, Domestic and Foreign; Why it Exists, and How it may be Extinguished (1853). 8vo. . . . $2.00
The Unity of Law: As Exhibited in the Relations of Physical, Social, Mental and Moral Science (1872). 8vo. . . $2.50

CLARK.—Tramways, their Construction and Working:
Embracing a Comprehensive History of the System. With an exhaustive analysis of the various modes of traction, including horse-power, steam, heated water and compressed air; a description of the varieties of Rolling stock, and ample details of cost and working expenses. By D. KINNEAR CLARK. Illustrated by over 200 wood engravings, and thirteen folding plates. 1 vol. 8vo. . $5.00

COLBURN.—The Locomotive Engine:
Including a Description of its Structure, Rules for Estimating its Capabilities, and Practical Observations on its Construction and Management. By ZERAH COLBURN. Illustrated. 12mo. . $1.00

COLLENS.—The Eden of Labor; or, the Christian Utopia.
By T. WHARTON COLLENS, author of "Humanics," "The History of Charity," etc. 12mo. Paper cover, $1.00; Cloth . $1.25

COOLEY.—A Complete Practical Treatise on Perfumery:
Being a Hand-book of Perfumes, Cosmetics and other Toilet Articles With a Comprehensive Collection of Formulæ. By ARNOLD J. COOLEY. 12mo. $1.50

COOPER.—A Treatise on the use of Belting for the Transmission of Power.
With numerous illustrations of approved and actual methods of arranging Main Driving and Quarter Twist Belts, and of Belt Fastenings. Examples and Rules in great number for exhibiting and calculating the size and driving power of Belts. Plain, Particular and Practical Directions for the Treatment, Care and Management of Belts. Descriptions of many varieties of Beltings, together with chapters on the Transmission of Power by Ropes; by Iron and Wood Frictional Gearing; on the Strength of Belting Leather; and on the Experimental Investigations of Morin, Briggs, and others. By JOHN H. COOPER, M. E. 8vo. $3.50

CRAIK.—The Practical American Millwright and Miller.
By DAVID CRAIK, Millwright. Illustrated by numerous wood engravings and two folding plates. 8vo. . . . . (Scarce.)

CROSS.—The Cotton Yarn Spinner:
Showing how the Preparation should be arranged for Different Counts of Yarns by a System more uniform than has hitherto been practiced; by having a Standard Schedule from which we make all our Changes. By RICHARD CROSS. 122 pp. 12mo. . 75

CRISTIANI.—A Technical Treatise on Soap and Candles:
With a Glance at the Industry of Fats and Oils. By R. S. CRISTIANI, Chemist. Author of "Perfumery and Kindred Arts." Illustrated by 176 engravings. 581 pages, 8vo. $15.00

COURTNEY.—The Boiler Maker's Assistant in Drawing, Templating, and Calculating Boiler Work and Tank Work, etc.
Revised by D. K. CLARK. 102 ills. Fifth edition. . . . 80

COURTNEY.—The Boiler Maker's Ready Reckoner:
With Examples of Practical Geometry and Templating. Revised by D. K. CLARK, C. E. 37 illustrations. Fifth edition. . $1.60

DAVIDSON.—A Practical Manual of House Painting, Graining, Marbling, and Sign-Writing:
Containing full information on the processes of House Painting in Oil and Distemper, the Formation of Letters and Practice of Sign-Writing, the Principles of Decorative Art, a Course of Elementary Drawing for House Painters, Writers, etc., and a Collection of Useful Receipts. With nine colored illustrations of Woods and Marbles, and numerous wood engravings. By ELLIS A. DAVIDSON. 12mo. $2.00

DAVIES.—A Treatise on Earthy and Other Minerals and Mining:
By D. C. DAVIES, F. G. S., Mining Engineer, etc. Illustrated by 76 Engravings. 12mo. $5.00

DAVIES.—A Treatise on Metalliferous Minerals and Mining:
By D. C. DAVIES, F. G. S., Mining Engineer, Examiner of Mines, Quarries and Collieries. Illustrated by 148 engravings of Geological Formations, Mining Operations and Machinery, drawn from the practice of all parts of the world. Fifth Edition, thoroughly Revised and much Enlarged by his son, E. Henry Davies. 12mo., 524 pages $5.00

DAVIES.—A Treatise on Slate and Slate Quarrying:
Scientific, Practical and Commercial. By D. C. DAVIES, F. G. S., Mining Engineer, etc. With numerous illustrations and folding plates. 12mo. $1.20

DAVIS.—A Practical Treatise on the Manufacture of Brick, Tiles and Terra-Cotta:
Including Stiff Clay, Dry Clay, Hand Made, Pressed or Front, and Roadway Paving Brick, Enamelled Brick, with Glazes and Colors, Fire Brick and Blocks, Silica Brick, Carbon Brick, Glass Pots, Re-

torts, Architectural Terra-Cotta, Sewer Pipe, Drain Tile, Glazed and Unglazed Roofing Tile, Art Tile, Mosaics, and Imitation of Intarsia or Inlaid Surfaces. Comprising every product of Clay employed in Architecture, Engineering, and the Blast Furnace. With a Detailed Description of the Different Clays employed, the Most Modern Machinery, Tools, and Kilns used, and the Processes for Handling, Disintegrating, Tempering, and Moulding the Clay into Shape, Drying, Setting, and Burning. By Charles Thomas Davis. Third Edition. Revised and in great part rewritten. Illustrated by 261 engravings. 662 pages $12.50

DAVIS.—A Treatise on Steam-Boiler Incrustation and Methods for Preventing Corrosion and the Formation of Scale:
By CHARLES T. DAVIS. Illustrated by 65 engravings. 8vo.

DAVIS.—The Manufacture of Paper:
Being a Description of the various Processes for the Fabrication, Coloring and Finishing of every kind of Paper, Including the Different Raw Materials and the Methods for Determining their Values, the Tools, Machines and Practical Details connected with an intelligent and a profitable prosecution of the art, with special reference to the best American Practice. To which are added a History of Paper, complete Lists of Paper-Making Materials, List of American Machines, Tools and Processes used in treating the Raw Materials, and in Making, Coloring and Finishing Paper. By CHARLES T. DAVIS. Illustrated by 156 engravings. 608 pages, 8vo. $6.00

DAVIS.—The Manufacture of Leather:
Being a Description of all the Processes for the Tanning and Tawing with Bark, Extracts, Chrome and all Modern Tannages in General Use, and the Currying, Finishing and Dyeing of Every Kind of Leather; Including the Various Raw Materlals, the Tools, Machines, and all Details of Importance Connected with an Intelligent and Profitable Prosecution of the Art, with Special Reference to the Best American Practice. To which are added Lists of American Patents (1884–1897) for Materials, Processes, Tools and Machines for Tanning, Currying, etc. By CHARLES THOMAS DAVIS. Second Edition, Revised, and in great part Rewritten. Illustrated by 147 engravings and 14 Samples of Quebracho Tanned and Aniline Dyed Leathers. 8vo, cloth, 712 pages. Price $10.00

DAWIDOWSKY—BRANNT.—A Practical Treatise on the Raw Materials and Fabrication of Glue, Gelatine, Gelatine Veneers and Foils, Isinglass, Cements, Pastes, Mucilages, etc.:
Based upon Actual Experience. By F. DAWIDOWSKY, Technical Chemist. Translated from the German, with extensive additions, including a description of the most Recent American Processes, by WILLIAM T. BRANNT. 2d revised edition, 350 pages. (1905.) Price $3.00

DE GRAFF.—The Geometrical Stair-Builders' Guide:
Being a Plain Practical System of Hand-Railing, embracing all its necessary Details, and Geometrically Illustrated by twenty-two Steel Engravings; together with the use of the most approved principles of Practical Geometry By SIMON DE GRAFF, Architect (Scarce.)

DE KONINCK—DIETZ.—A Practical Manual of Chemical Analysis and Assaying:

As applied to the Manufacture of Iron from its Ores, and to Cast Iron, Wrought Iron, and Steel, as found in Commerce. By L. L. De Koninck, Dr. Sc., and E. Dietz, Engineer. Edited with Notes, by Robert Mallet, F. R. S., F. S. G., M. I. C. E., etc. American Edition, Edited with Notes and an Appendix on Iron Ores, by A. A. Fesquet, Chemist and Engineer. 12mo. . . . $1.50

UNCAN.—Practical Surveyor's Guide:

Containing the necessary information to make any person of common capacity, a finished land surveyor without the aid of a teacher. By Andrew Duncan. Revised. 72 engravings, 214 pp. 12mo. $1.50

DUPLAIS.—A Treatise on the Manufacture and Distillation of Alcoholic Liquors:

Comprising Accurate and Complete Details in Regard to Alcohol from Wine, Molasses, Beets, Grain, Rice, Potatoes, Sorghum, Asphodel, Fruits, etc.; with the Distillation and Rectification of Brandy, Whiskey, Rum, Gin, Swiss Absinthe, etc., the Preparation of Aromatic Waters, Volatile Oils or Essences, Sugars, Syrups, Aromatic Tinctures, Liqueurs, Cordial Wines, Effervescing Wines, etc., the Ageing of Brandy and the improvement of Spirits, with Copious Directions and Tables for Testing and Reducing Spirituous Liquors, etc., etc. Translated and Edited from the French of MM. Duplais, By M. McKennie, M. D. Illustrated 743 pp. 8vo. $15.00

DYER AND COLOR-MAKER'S COMPANION:

Containing upwards of two hundred Receipts for making Colors, on the most approved principles, for all the various styles and fabrics now in existence; with the Scouring Process, and plain Directions for Preparing, Washing-off, and Finishing the Goods. 12mo. $1 00

EIDHERR.—The Techno-Chemical Guide to Distillation:

A Hand-Book for the Manufacture of Alcohol and Alcoholic Liquors, including the Preparation of Malt and Compressed Yeast. Edited from the German of Ed. Eidherr.

EDWARDS.—A Catechism of the Marine Steam-Engine,

For the use of Engineers, Firemen, and Mechanics. A Practical Work for Practical Men. By Emory Edwards, Mechanical Engineer. Illustrated by sixty-three Engravings, including examples of the most modern Engines. Third edition, thoroughly revised, with much additional matter. 12mo. 414 pages . . . $2 00

EDWARDS.—Modern American Locomotive Engines,

Their Design, Construction and Management. By Emory Edwards. Illustrated 12mo. $2.00

EDWARDS.—The American Steam Engineer:

Theoretical and Practical, with examples of the latest and most approved American practice in the design and construction of Steam Engines and Boilers. For the use of engineers, machinists, boiler-makers, and engineering students. By Emory Edwards. Fully illustrated, 419 pages. 12mo. $2.50

EDWARDS.—Modern American Marine Engines, Boilers, and Screw Propellers,

Their Design and Construction. Showing the Present Practice of the most Eminent Engineers and Marine Engine Builders in the United States. Illustrated by 30 large and elaborate plates. 4to. $5.00

EDWARDS.—The Practical Steam Engineer's Guide

In the Design, Construction, and Management of American Stationary, Portable, and Steam Fire-Engines, Steam Pumps, Boilers, Injectors, Governors, Indicators, Pistons and Rings, Safety Valves and Steam Gauges. For the use of Engineers, Firemen, and Steam Users. By EMORY EDWARDS. Illustrated by 119 engravings. 420 pages. 12mo. $2 50

EISSLER.—The Metallurgy of Silver:

A Practical Treatise on the Amalgamation, Roasting, and Lixiviation of Silver Ores, including the Assaying, Melting, and Refining of Silver Bullion. By M. EISSLER. 124 Illustrations. 336 pp. 12mo. $4.25

ELDER.—Conversations on the Principal Subjects of Political Economy.

By DR. WILLIAM ELDER. 8vo. $2.50

ELDER.—Questions of the Day,

Economic and Social. By DR. WILLIAM ELDER. 8vo. . $3.00

ERNI AND BROWN.—Mineralogy Simplified.

Easy Methods of Identifying Minerals, including Ores, by Means of the Blow-pipe, by Flame Reactions, by Humid Chemical Analysis, and by Physical Tests. By HENRI ERNI, A. M., M. D. Third Edition, revised, re-arranged and with the addition of entirely new matter, including Tables for the Determination of Minerals by Chemical and Pyrognostic Characters, and by Physical Characters By AMOS P. BROWN, E. M., Ph. D. 350 pp., illustrated by 96 engravings, pocket-book form, full flexible morocco, gilt edges . . . $2.50

FAIRBAIRN. The Principles of Mechanism and Machinery of Transmission:

Comprising the Principles of Mechanism, Wheels, and Pulleys, Strength and Proportion of Shafts, Coupling of Shafts, and Engaging and Disengaging Gear. By SIR WILLIAM FAIRBAIRN, Bart. C. E. Beautifully illustrated by over 150 wood-cuts. In one volume, 12mo. $2.00

FLEMING.—Narrow Gauge Railways in America:

A Sketch of their Rise, Progress, and Success. Valuable Statistics as to Grades, Curves, Weight of Rail, Locomotives, Cars, etc. By HOWARD FLEMING. Illustrated, 8vo. $1.00

FORSYTH.—Book of Designs for Headstones, Mural, and other Monuments:

Containing 78 Designs. By JAMES FORSYTH, With an Introduction by CHARLES BOUTELL, M. A. 4to., cloth . . . $3.50

FRIEDBERG. Utilization of Bones by Chemical Means; especially the Modes of Obtaining Fat, Glue, Manures, Phosphorus and Phosphates.

Illustrated. 8vo. (In preparation.)

FRANKEL—HUTTER.—A Practical Treatise on the Manufacture of Starch, Glucose, Starch-Sugar, and Dextrine:
Based on the German of LADISLAUS VON WAGNER, Professor in the Royal Technical High School, Buda-Pest, Hungary, and other authorities. By JULIUS FRANKEL, Graduate of the Polytechnic School of Hanover. Edited by ROBERT HUTTER, Chemist, Practical Manufacturer of Starch-Sugar. Illustrated by 58 engravings, covering every branch of the subject, including examples of the most Recent and Best American Machinery. 8vo., 344 pp. $6.00

GARDNER.—The Painter's Encyclopædia:
Containing Definitions of all Important Words in the Art of Plain and Artistic Painting, with Details of Practice in Coach, Carriage, Railway Car, House, Sign, and Ornamental Painting, including Graining, Marbling, Staining, Varnishing, Polishing, Lettering, Stenciling, Gilding, Bronzing, etc. By FRANKLIN B. GARDNER. 158 Illustrations. 12mo. 427 pp. $2.00

GARDNER.—Everybody's Paint Book:
A Complete Guide to the Art of Outdoor and Indoor Painting. 38 illustrations. 12mo, 183 pp. $1.00

GEE.—The Jeweller's Assistant in the Art of Working in Gold:
A Practical Treatise for Masters and Workmen. 12mo. . $3.00

GEE.—The Goldsmith's Handbook:
Containing full instructions for the Alloying and Working of Gold, including the Art of Alloying, Melting, Reducing, Coloring, Collecting, and Refining; the Processes of Manipulation, Recovery of Waste; Chemical and Physical Properties of Gold; with a New System of Mixing its Alloys; Solders, Enamels, and other Useful Rules and Recipes. By GEORGE E. GEE. 12mo. . . $1.25

GEE.—The Silversmith's Handbook:
Containing full instructions for the Alloying and Working of Silver, including the different modes of Refining and Melting the Metal; its Solders; the Preparation of Imitation Alloys; Methods of Manipulation; Prevention of Waste; Instructions for Improving and Finishing the Surface of the Work; together with other Useful Information and Memoranda. By GEORGE E. GEE. Illustrated. 12mo. $1.25

GOTHIC ALBUM FOR CABINET-MAKERS:
Designs for Gothic Furniture. Twenty-three plates. Oblong $1.50

GRANT.—A Handbook on the Teeth of Gears:
Their Curves, Properties, and Practical Construction. By GEORGE B. GRANT. Illustrated. Third Edition, enlarged. 8vo. $1.00

GREENWOOD.—Steel and Iron:
Comprising the Practice and Theory of the Several Methods Pursued in their Manufacture, and of their Treatment in the Rolling-Mills, the Forge, and the Foundry. By WILLIAM HENRY GREENWOOD, F. C. S. With 97 Diagrams, 536 pages. 12mo. $1.75

GREGORY.—Mathematics for Practical Men:

Adapted to the Pursuits of Surveyors, Architects, Mechanics, and Civil Engineers. By OLINTHUS GREGORY. 8vo., plates $3.00

GRISWOLD.—Railroad Engineer's Pocket Companion for the Field:

Comprising Rules for Calculating Deflection Distances and Angles, Tangential Distances and Angles, and all Necessary Tables for Engineers; also the Art of Levelling from Preliminary Survey to the Construction of Railroads, intended Expressly for the Young Engineer, together with Numerous Valuable Rules and Examples. By W. GRISWOLD. 12mo., tucks $1.50

GRUNER.—Studies of Blast Furnace Phenomena:

By M. L. GRUNER, President of the General Council of Mines of France, and lately Professor of Metallurgy at the Ecole des Mines. Translated, with the author's sanction, with an Appendix, by L. D. B. GORDON, F. R. S. E., F. G. S. 8vo. . . . $2.50

Hand-Book of Useful Tables for the Lumberman, Farmer and Mechanic:

Containing Accurate Tables of Logs Reduced to Inch Board Measure, Plank, Scantling and Timber Measure; Wages and Rent, by Week or Month; Capacity of Granaries, Bins and Cisterns; Land Measure, Interest Tables, with Directions for Finding the Interest on any sum at 4, 5, 6, 7 and 8 per cent., and many other Useful Tables. 32 mo., boards. 186 pages 25

HASERICK.—The Secrets of the Art of Dyeing Wool, Cotton, and Linen,

Including Bleaching and Coloring Wool and Cotton Hosiery and Random Yarns. A Treatise based on Economy and Practice. By E. C. HASERICK. *Illustrated by 323 Dyed Patterns of the Yarns or Fabrics.* 8vo. $5.00

HATS AND FELTING:

A Practical Treatise on their Manufacture. By a Practical Hatter. Illustrated by Drawings of Machinery, etc. 8vo. . . $1.00

HERMANN.—Painting on Glass and Porcelain, and Enamel Painting:

A Complete Introduction to the Preparation of all the Colors and Fluxes Used for Painting on Glass, Porcelain, Enamel, Faience and Stoneware, the Color Pastes and Colored Glasses, together with a Minute Description of the Firing of Colors and Enamels, on the Basis of Personal Practical Experience of the Art up to Date. 18 illustrations. Second edition. . . . . . .

HAUPT.—Street Railway Motors:

With Descriptions and Cost of Plants and Operation of the Various Systems now in Use. 12mo. $1.75

HAUPT.—A Manual of Engineering Specifications and Contracts.

By LEWIS M. HAUPT, C. E. Illustrated with numerous maps. 328pp. 8vo. $3 00

HAUPT.—The Topographer, His Instruments and Methods.

By LEWIS M. HAUPT, A. M., C. E. Illustrated with numerous plates, maps and engravings. 247 pp. 8vo. $3.00

HUGHES.—American Miller and Millwright's Assistant:

By WILLIAM CARTER HUGHES. 12mo. $1.50

HULME.—Worked Examination Questions in Plane Geometrical Drawing:

For the Use of Candidates for the Royal Military Academy, Woolwich; the Royal Military College, Sandhurst; the Indian Civil Engineering College, Cooper's Hill; Indian Public Works and Telegraph Departments; Royal Marine Light Infantry; the Oxford and Cambridge Local Examinations, etc. By F. EDWARD HULME, F. L. S., F. S. A., Art-Master Marlborough College. Illustrated by 300 examples. Small quartc $1.r

ERVIS.—Railroad Property:

A Treatise on the Construction and Management of Railways; designed to afford useful knowledge, in the popular style, to the holders of this class of property; as well as Railway Managers, Officers, and Agents. By JOHN B. JERVIS, late Civil Engineer of the Hudson River Railroad, Croton Aqueduct, etc. 12mo., cloth $1.50

KEENE.—A Hand-Book of Practical Gauging:

For the Use of Beginners, to which is added a Chapter on Distillation, describing the process in operation at the Custom-House for ascertaining the Strength of Wines. By JAMES B. KEENE, of H. M. Customs. 8vo. $1 00

KELLEY.—Speeches, Addresses, and Letters on Industrial and Financial Questions:

By HON. WILLIAM D. KELLEY, M. C. 544 pages, 8vo. . $2.50

KELLOGG.—A New Monetary System:

The only means of Securing the respective Rights of Labor and Property, and of Protecting the Public from Financial Revulsions. By EDWARD KELLOGG. 12mo. Paper cover, $1.00. Bound in cloth. $1.25

KEMLO.—Watch-Repairer's Hand-Book:

Being a Complete Guide to the Young Beginner, in Taking Apart, Putting Together, and Thoroughly Cleaning the English Lever and other Foreign Watches, and all American Watches. By F. KEMLO, Practical Watchmaker. With Illustrations. 12mo. $1.25

KENTISH.—A Treatise on a Box of Instruments,

And the Slide Rule; with the Theory of Trigonometry and Logarithms, including Practical Geometry, Surveying, Measuring of Timber, Cask and Malt Gauging, Heights, and Distances. By THOMAS KENTISH. In one volume. 12mo. $1.00

KERL.—The Assayer's Manual:

An Abridged Treatise on the Docimastic Examination of Ores, and Furnace and other Artificial Products. By BRUNO KERL, Professor in the Royal School of Mines. Translated from the German by WILLIAM T. BRANNT. Second American edition, edited with Extensive Additions by F. LYNWOOD GARRISON, Member of the American Institute of Mining Engineers, etc. Illustrated by 87 engravings. 8vo. (Third Edition in preparation.)

KICK.—Flour Manufacture.

A Treatise on Milling Science and Practice. By FREDERICK KICK Imperial Regierungsrath, Professor of Mechanical Technology in the Imperial German Polytechnic Institute, Prague. Translated from the second enlarged and revised edition with supplement by H. H. P. POWLES, Assoc. Memb. Institution of Civil Engineers. Illustrated with 28 Plates, and 167 Wood-cuts. 367 pages. 8vo. . $10.00

KINGZETT.—The History, Products, and Processes of the Alkali Trade:

Including the most Recent Improvements. By CHARLES THOMAS KINGZETT. Consulting Chemist. With 23 illustrations. 8vo. $2.50

KIRK.—The Cupola Furnace:

A Practical Treatise on the Construction and Management of Foundry Cupolas. By EDWARD KIRK, Practical Moulder and Melter, Consulting Expert in Melting. Illustrated by 78 engravings. Second Edition, revised and enlarged. 450 pages. 8vo. 1903. $3.50

LANDRIN.—A Treatise on Steel:

Comprising its Theory, Metallurgy, Properties, Practical Working, and Use. By M. H. C. LANDRIN, JR. From the French, by A. A. FESQUET. 12mo. $2.50

LANGBEIN.—A Complete Treatise on the Electro-Deposition of Metals:

Comprising Electro-Plating and Galvanoplastic Operations, the Deposition of Metals by the Contact and Immersion Processes, the Coloring of Metals, the Methods of Grinding and Polishing, as well as Descriptions of the Electric Elements, Dynamo-Electric Machines, Thermo-Piles and of the Materials and Processes used in Every Department of the Art. From the German of DR. GEORGE LANGBEIN, with additions by WM. T. BRANNT. Fifth Edition, thoroughly revised and much enlarged. 170 Engravings. 694 pages 8vo. 1905. $4.00

LARDNER.—The Steam-Engine:

For the Use of Beginners. Illustrated. 12mo. 60

LEHNER.—The Manufacture of Ink:

Comprising the Raw Materials, and the Preparation of Writing, Copying and Hektograph Inks, Safety Inks, Ink Extracts and Powders, etc. Translated from the German of SIGMUND LEHNER, with additions by WILLIAM T. BRANNT. Illustrated. 12mo. $2.00

LARKIN.—The Practical Brass and Iron Founder's Guide:
A Concise Treatise on Brass Founding, Moulding, the Metals and their Alloys, etc.; to which are added Recent Improvements in the Manufacture of Iron, Steel by the Bessemer Process, etc., etc. By JAMES LARKIN, late Conductor of the Brass Foundry Department in Reany, Neafie & Co.'s Penn Works, Philadelphia. New edition, revised, with extensive additions. 414 pages. 12mo. . $2.50

LEROUX.—A Practical Treatise on the Manufacture of Worsteds and Carded Yarns:
Comprising Practical Mechanics, with Rules and Calculations applied to Spinning; Sorting, Cleaning, and Scouring Wools; the English and French Methods of Combing, Drawing, and Spinning Worsteds, and Manufacturing Carded Yarns. Translated from the French of CHARLES LEROUX, Mechanical Engineer and Superintendent of a Spinning-Mill, by HORATIO PAINE, M. D., and A. A. FESQUET, Chemist and Engineer. Illustrated by twelve large Plates. To which is added an Appendix, containing Extracts from the Reports of the International Jury, and of the Artisans selected by the Committee appointed by the Council of the Society of Arts, London, on Woolen and Worsted Machinery and Fabrics, as exhibited in the Paris Universal Exposition, 1867. 8vo. $5.00

LEFFEL.—The Construction of Mill-Dams:
Comprising also the Building of Race and Reservoir Embankments and Head-Gates, the Measurement of Streams, Gauging of Water Supply, etc. By JAMES LEFFEL & Co. Illustrated by 58 engravings. 8vo. . . . . (Scarce.)

LESLIE.—Complete Cookery:
Directions for Cookery in its Various Branches. By MISS LESLIE. Sixtieth thousand. Thoroughly revised, with the addition of New Receipts. 12mo. $1.50

LE VAN.—The Steam Engine and the Indicator:
Their Origin and Progressive Development; including the Most Recent Examples of Steam and Gas Motors, together with the Indicator, its Principles, its Utility, and its Application. By WILLIAM BARNET LE VAN. Illustrated by 205 Engravings, chiefly of Indicator-Cards. 469 pp. 8vo. $2.00

LIEBER.—Assayer's Guide:
Or, Practical Directions to Assayers, Miners, and Smelters, for the Tests and Assays, by Heat and by Wet Processes, for the Ores of all the principal Metals, of Gold and Silver Coins and Alloys, and of Coal, etc. By OSCAR M. LIEBER. Revised. 283 pp. 12mo. $1.50

Lockwood's Dictionary of Terms:
Used in the Practice of Mechanical Engineering, embracing those Current in the Drawing Office, Pattern Shop, Foundry, Fitting, Turning, Smith's and Boiler Shops, etc., etc., comprising upwards of Six Thousand Definitions. Edited by a Foreman Pattern Maker, author of "Pattern Making." 417 pp. 12mo. . . . $3.75

LUKIN.—The Lathe and Its Uses:
Or Instruction in the Art of Turning Wood and Metal. Including a Description of the Most Modern Appliances for the Ornamentation of Plane and Curved Surfaces, an Entirely Novel Form of Lathe for Eccentric and Rose-Engine Turning; A Lathe and Planing Machine Combined; and Other Valuable Matter Relating to the Art. Illustrated by 462 engravings. Seventh edition. 315 pages. 8vo. $4.25

MAIN and BROWN.—Questions on Subjects Connected with the Marine Steam-Engine:
And Examination Papers; with Hints for their Solution. By THOMAS J. MAIN, Professor of Mathematics, Royal Naval College, and THOMAS BROWN, Chief Engineer, R. N. 12mo., cloth . $1.00

MAIN and BROWN.—The Indicator and Dynamometer:
With their Practical Applications to the Steam-Engine. By THOMAS J. MAIN, M. A. F. R., Ass't S. Professor Royal Naval College, Portsmouth, and THOMAS BROWN, Assoc. Inst. C. E., Chief Engineer R. N., attached to the R. N. College. Illustrated. 8vo. .

MAIN and BROWN.—The Marine Steam-Engine.
By THOMAS J. MAIN, F. R. Ass't S. Mathematical Professor at the Royal Naval College, Portsmouth, and THOMAS BROWN, Assoc. Inst. C. E., Chief Engineer R. N. Attached to the Royal Naval College. With numerous illustrations. 8vo. . .

MAKINS.—A Manual of Metallurgy:
By GEORGE HOGARTH MAKINS. 100 engravings. Second edition rewritten and much enlarged. 12mo., 592 pages . .

MARTIN.—Screw-Cutting Tables, for the Use of Mechanical Engineers:
Showing the Proper Arrangement of Wheels for Cutting the Threads of Screws of any Required Pitch; with a Table for Making the Universal Gas-Pipe Thread and Taps. By W. A. MARTIN, Engineer. 8vo. 50

MICHELL.—Mine Drainage:
Being a Complete and Practical Treatise on Direct-Acting Underground Steam Pumping Machinery. With a Description of a large number of the best known Engines, their General Utility and the Special Sphere of their Action, the Mode of their Application, and their Merits compared with other Pumping Machinery. By STEPHEN MICHELL. Illustrated by 247 engravings. 8vo., 369 pages. $12 50

MOLESWORTH.—Pocket-Book of Useful Formulæ and Memoranda for Civil and Mechanical Engineers.
By GUILFORD L. MOLESWORTH, Member of the Institution of Civil Engineers, Chief Resident Engineer of the Ceylon Railway. Full-bound in Pocket-book form $1.00

MOORE.—The Universal Assistant and the Complete Mechanic:

Containing over one million Industrial Facts, Calculations, Receipts, Processes, Trades Secrets, Rules, Business Forms, Legal Items, Etc., in every occupation, from the Household to the Manufactory. By R. MOORE. Illustrated by 500 Engravings. 12mo. . $2.50

MORRIS.—Easy Rules for the Measurement of Earthworks:

By means of the Prismoidal Formula. Illustrated with Numerous Wood-Cuts, Problems, and Examples, and concluded by an Extensive Table for finding the Solidity in cubic yards from Mean Areas. The whole being adapted for convenient use by Engineers, Surveyors, Contractors, and others needing Correct Measurements of Earthwork. By ELWOOD MORRIS, C. E. 8vo. $1.50

MAUCHLINE.—The Mine Foreman's Hand-Book

Of Practical and Theoretical Information on the Opening, Ventilating, and Working of Collieries. Questions and Answers on Practical and Theoretical Coal Mining. Designed to Assist Students and Others in Passing Examinations for Mine Foremanships. By ROBERT MAUCHLINE. 3d Edition. Thoroughly Revised and Enlarged by F. ERNEST BRACKETT. 134 engravings, 8vo. 378 pages. (1905) $3.75

NAPIER.—A System of Chemistry Applied to Dyeing.

By JAMES NAPIER, F. C. S. A New and Thoroughly Revised Edition. Completely brought up to the present state of the Science, including the Chemistry of Coal Tar Colors, by A. A. FESQUET, Chemist and Engineer. With an Appendix on Dyeing and Calico Printing, as shown at the Universal Exposition, Paris, 1867. Illustrated. 8vo. 422 pages $3.00

NEVILLE.—Hydraulic Tables, Coefficients, and Formulæ, for finding the Discharge of Water from Orifices, Notches Weirs, Pipes, and Rivers:

Third Edition, with Additions, consisting of New Formulæ for the Discharge from Tidal and Flood Sluices and Siphons; general information on Rainfall, Catchment-Basins, Drainage, Sewerage, Water Supply for Towns and Mill Power. By JOHN NEVILLE, C. E. M. R. I. A.; Fellow of the Royal Geological Society of Ireland. Thick 12mo. $5.50

NEWBERY.—Gleanings from Ornamental Art of every style:

Drawn from Examples in the British, South Kensington, Indian, Crystal Palace, and other Museums, the Exhibitions of 1851 and 1862, and the best English and Foreign works. In a series of 100 exquisitely drawn Plates, containing many hundred examples. By ROBERT NEWBERY. 4to, ... (Scarce.)

NICHOLLS.—The Theoretical and Practical Boiler-Maker and Engineer's Reference Book:

Containing a variety of Useful Information for Employers of Labor Foremen and Working Boiler-Makers Iron, Copper, and Tinsmiths

Draughtsmen, Engineers, the General Steam-using Public, and for the Use of Science Schools and Classes. By SAMUEL NICHOLLS. Illustrated by sixteen plates, 12mo. $2.50

NICHOLSON.—A Manual of the Art of Bookbinding:
Containing full instructions in the different Branches of Forwarding, Gilding, and Finishing. Also, the Art of Marbling Book-edges and Paper. By JAMES B. NICHOLSON. Illustrated. 12mo., cloth $2.25

NICOLLS.—The Railway Builder:
A Hand-Book for Estimating the Probable Cost of American Railway Construction and Equipment. By WILLIAM J. NICOLLS, Civil Engineer. Illustrated, full bound, pocket-book form . $2.00

NORMANDY.—The Commercial Handbook of Chemical Analysis:
Or Practical Instructions for the Determination of the Intrinsic or Commercial Value of Substances used in Manufactures, in Trades, and in the Arts. By A. NORMANDY. New Edition, Enlarged, and to a great extent rewritten. By HENRY M. NOAD, Ph.D., F.R.S., thick 12mo. . . . . Scarce

NORRIS.—A Handbook for Locomotive Engineers and Machinists:
Comprising the Proportions and Calculations for Constructing Locomotives; Manner of Setting Valves; Tables of Squares, Cubes, Areas, etc., etc. By SEPTIMUS NORRIS, M. E. New edition. Illustrated, 12mo. $1.50

NYSTROM.—A New Treatise on Elements of Mechanics:
Establishing Strict Precision in the Meaning of Dynamical Terms: accompanied with an Appendix on Duodenal Arithmetic and Metrology. By JOHN W. NYSTROM, C. E. Illustrated. 8vo.

NYSTROM.—On Technological Education and the Construction of Ships and Screw Propellers:
For Naval and Marine Engineers. By JOHN W. NYSTROM, late Acting Chief Engineer, U. S. N. Second edition, revised, with additional matter. Illustrated by seven engravings. 12mo. . $1.

O'NEILL.—A Dictionary of Dyeing and Calico Printing:
Containing a brief account of all the Substances and Processes in use in the Art of Dyeing and Printing Textile Fabrics; with Practical Receipts and Scientific Information. By CHARLES O'NEILL, Analytical Chemist. To which is added an Essay on Coal Tar Colors and their application to Dyeing and Calico Printing. By A. A. FESQUET, Chemist and Engineer. With an appendix on Dyeing and Calico Printing, as shown at the Universal Exposition, Paris, 1867 8vo., 491 pages $3.00

ORTON.—Underground Treasures:
How and Where to Find Them. A Key for the Ready Determination of all the Useful Minerals within the United States. By JAMES ORTON, A.M., Late Professor of Natural History in Vassar College, N. Y; author of the "Andes and the Amazon," etc. A New Edition, with An Appendix on Ore Deposits and Testing Minerals (1901). Illustrated $1.50

OSBORN.—The Prospector's Field Book and Guide.
In the Search For and the Easy Determination of Ores and Other Useful Minerals. By Prof. H. S. OSBORN, LL. D. Illustrated by 66 Engravings. Sixth Edition. Revised and Enlarged. 360 pages, 12mo. (Dec., 1903) $1.50

OSBORN—A Practical Manual of Minerals, Mines and Mining:
Comprising the Physical Properties, Geologic Positions, Local Occurrence and Associations of the Useful Minerals; their Methods of Chemical Analysis and Assay; together with Various Systems of Excavating and Timbering, Brick and Masonry Work, during Driving, Lining, Bracing and other Operations, etc. By Prof. H. S. OSBORN, LL. D., Author of "The Prospector's Field-Book and Guide." 171 engravings. Second Edition, revised. 8vo. . . . $4.50

OVERMAN.—The Manufacture of Steel:
Containing the Practice and Principles of Working and Making Steel. A Handbook for Blacksmiths and Workers in Steel and Iron, Wagon Makers, Die Sinkers, Cutlers, and Manufacturers of Files and Hardware, of Steel and Iron, and for Men of Science and Art. By FREDERICK OVERMAN, Mining Engineer, Author of the "Manufacture of Iron," etc. A new, enlarged, and revised Edition. By A. A. FESQUET, Chemist and Engineer. 12mo. . . $1.50

OVERMAN.—The Moulder's and Founder's Pocket Guide:
A Treatise on Moulding and Founding in Green-sand, Dry-sand, Loam, and Cement; the Moulding of Machine Frames, Mill-gear, Hollow-ware, Ornaments, Trinkets, Bells, and Statues; Description of Moulds for Iron, Bronze, Brass, and other Metals; Plaster of Paris, Sulphur, Wax, etc.; the Construction of Melting Furnaces, the Melting and Founding of Metals; the Composition of Alloys and their Nature, etc., etc. By FREDERICK OVERMAN, M. E. A new Edition, to which is added a Supplement on Statuary and Ornamental Moulding, Ordnance, Malleable Iron Castings, etc. By A. A. FESQUET, Chemist and Engineer. Illustrated by 44 engravings. 12mo. . $2.00

PAINTER, GILDER, AND VARNISHER'S COMPANION.
Comprising the Manufacture and Test of Pigments, the Arts of Painting, Graining, Marbling, Staining, Sign-writing, Varnishing, Glass-staining, and Gilding on Glass; together with Coach Painting and Varnishing, and the Principles of the Harmony and Contrast of Colors. Twenty-seventh Edition. Revised, Enlarged, and in great part Rewritten. By WILLIAM T. BRANNT, Editor of "Varnishes, Lacquers, Printing Inks and Sealing Waxes." Illustrated. 395 pp. 12mo. $1.50

PALLETT.—The Miller's, Millwright's, and Engineer's Guide.
By HENRY PALLETT. Illustrated. 12mo. $2.00

PERCY.—The Manufacture of Russian Sheet-Iron.
By JOHN PERCY, M. D., F. R. S. Paper. . . . 25 cts.

PERKINS.—Gas and Ventilation:
Practical Treatise on Gas and Ventilation. Illustrated. 12mo. $1.25

PERKINS AND STOWE.—A New Guide to the Sheet-iron and Boiler Plate Roller:
Containing a Series of Tables showing the Weight of Slabs and Piles to Produce Boiler Plates, and of the Weight of Piles and the Sizes of Bars to produce Sheet-iron; the Thickness of the Bar Gauge in decimals; the Weight per foot, and the Thickness on the Bar or Wire Gauge of the fractional parts of an inch; the Weight per sheet, and the Thickness on the Wire Gauge of Sheet-iron of various dimensions to weigh 112 lbs. per bundle; and the conversion of Short Weight into Long Weight, and Long Weight into Short. $1.50

POSSELT.—Recent Improvements in Textile Machinery Relating to Weaving:
Giving the Most Modern Points on the Construction of all Kinds of Looms, Warpers, Beamers, Slashers, Winders, Spoolers, Reeds, Temples, Shuttles, Bobbins, Heddles, Heddle Frames, Pickers, Jacquards, Card Stampers, etc., etc. 600 illus. . . $3 00

POSSELT.—Technology of Textile Design:
The Most Complete Treatise on the Construction and Application of Weaves for all Textile Fabrics and the Analysis of Cloth. By E. A. Posselt. 1,500 illustrations. 4to. $5.00

POSSELT.—Textile Calculations:
A Guide to Calculations Relating to the Manufacture of all Kinds of Yarns and Fabrics, the Analysis of Cloth, Speed, Power and Belt Calculations. By E. A. POSSELT. Illustrated. 4to. . $2.00

REGNAULT.—Elements of Chemistry:
By M. V. REGNAULT. Translated from the French by T. FORREST BETTON, M. D., and edited, with Notes, by JAMES C. BOOTH, Melter and Refiner U. S. Mint, and WILLIAM L. FABER, Metallurgist and Mining Engineer. Illustrated by nearly 700 wood-engravings. Comprising nearly 1,500 pages. In two volumes, 8vo., cloth . $6.00

RICHARDS.—Aluminium:
Its History, Occurrence, Properties, Metallurgy and Applications, including its Alloys. By JOSEPH W. RICHARDS, A. C., Chemist and Practical Metallurgist, Member of the Deutsche Chemische Gesellschaft. Illust. Third edition, enlarged and revised (1895) . $6.00

RIFFAULT, VERGNAUD, and TOUSSAINT.—A Practical Treatise on the Manufacture of Colors for Painting:
Comprising the Origin, Definition, and Classification of Colors; the Treatment of the Raw Materials; the best Formulæ and the Newest Processes for the Preparation of every description of Pigment, and the Necessary Apparatus and Directions for its Use; Dryers; the Testing, Application, and Qualities of Paints, etc., etc. By MM. RIFFAULT, VERGNAUD, and TOUSSAINT. Revised and Edited by M.

F. MALEPEYRE. Translated from the French, by A. A. FESQUET, Chemist and Engineer. Illustrated by Eighty engravings. In one vol., 8vo., 659 pages $5.00

ROPER.—Catechism for Steam Engineers and Electricians:
Including the Construction and Management of Steam Engines, Steam Boilers and Electric Plants. By STEPHEN ROPER. Twenty-first edition, rewritten and greatly enlarged by E. R. KELLER and C. W. PIKE. 365 pages. Illustrations. 18mo., tucks, gilt. $2.00

ROPER.—Engineer's Handy Book:
Containing Facts, Formulæ, Tables and Questions on Power, its Generation, Transmission and Measurement; Heat, Fuel, and Steam; The Steam Boiler and Accessories; Steam Engines and their Parts; Steam Engine Indicator; Gas and Gasoline Engines; Materials; their Properties and Strength; Together with a Discussion of the Fundamental Experiments in Electricity, and an Explanation of Dynamos, Motors, Batteries, etc., and Rules for Calculating Sizes of Wires. By STEPHEN ROPER. 15th edition. Revised and enlarged by E. R. KELLER, M. E. and C. W. PIKE, B. S. (1899), with numerous illustrations. Pocket-book form. Leather. $3.50

ROPER.—Hand-Book of Land and Marine Engines:
Including the Modelling, Construction, Running, and Management of Land and Marine Engines and Boilers. With illustrations. By STEPHEN ROPER, Engineer. Sixth edition. 12mo., tucks, gilt edge. $3.50

ROPER.—Hand-Book of the Locomotive:
Including the Construction of Engines and Boilers, and the Construction, Management, and Running of Locomotives. By STEPHEN ROPER. Eleventh edition. 18mo., tucks, gilt edge . $2.50

ROPER.—Hand-Book of Modern Steam Fire-Engines.
With illustrations. By STEPHEN ROPER, Engineer. Fourth edition, 12mo., tucks, gilt edge $3.50

ROPER.—Questions and Answers for Engineers.
This little book contains all the Questions that Engineers will be asked when undergoing an Examination for the purpose of procuring Licenses, and they are so plain that any Engineer or Fireman of ordinary intelligence may commit them to memory in a short time. By STEPHEN ROPER, Engineer. Third edition . . . $2.00

ROPER.—Use and Abuse of the Steam Boiler.
By STEPHEN ROPER, Engineer. Eighth edition, with illustrations. 18mo., tucks, gilt edge $2.00

ROSE.—The Complete Practical Machinist:
Embracing Lathe Work, Vise Work, Drills and Drilling, Taps and Dies, Hardening and Tempering, the Making and Use of Tools Tool Grinding, Marking out Work, Machine Tools, etc. By JOSHUA ROSE. 395 Engravings. Nineteenth Edition, greatly Enlarged with New and Valuable Matter. 12mo., 504 pages. . . $2.50

ROSE.—Mechanical Drawing Self-Taught:
Comprising Instructions in the Selection and Preparation of Drawing Instruments, Elementary Instruction in Practical Mechanical Draw-

ing, together with Examples in Simple Geometry and Elementary Mechanism, including Screw Threads, Gear Wheels, Mechanical Motions, Engines and Boilers. By JOSHUA ROSE, M. E. Illustrated by 330 engravings. 8vo., 313 pages $4.00

ROSE.—The Slide-Valve Practically Explained:
Embracing simple and complete Practical Demonstrations of the operation of each element in a Slide-valve Movement, and illustrating the effects of Variations in their Proportions by examples carefully selected from the most recent and successful practice. By JOSHUA ROSE, M. E. Illustrated by 35 engravings . . $1.00

ROSS.—The Blowpipe in Chemistry, Mineralogy and Geology:
Containing all Known Methods of Anhydrous Analysis, many Working Examples, and Instructions for Making Apparatus. By LIEUT.-COLONEL W. A. ROSS, R. A., F. G. S. With 120 Illustrations. 12mo. $2.00

SHAW.—Civil Architecture:
Being a Complete Theoretical and Practical System of Building, containing the Fundamental Principles of the Art. By EDWARD SHAW, Architect. To which is added a Treatise on Gothic Architecture, etc. By THOMAS W. SILLOWAY and GEORGE M. HARDING, Architects. The whole illustrated by 102 quarto plates finely engraved on copper. Eleventh edition. 4to. $6.00

SHUNK.—A Practical Treatise on Railway Curves and Location, for Young Engineers.
By W. F. SHUNK, C. E. 12mo. Full bound pocket-book form $2.00

SLATER.—The Manual of Colors and Dye Wares.
By J. W. SLATER. 12mo. $3.00

SLOAN.—American Houses:
A variety of Original Designs for Rural Buildings. Illustrated by 26 colored engravings, with descriptive references. By SAMUEL SLOAN, Architect. 8vo. 75

SLOAN.—Homestead Architecture:
Containing Forty Designs for Villas, Cottages, and Farm-houses, with Essays on Style, Construction, Landscape Gardening, Furniture, etc., etc. Illustrated by upwards of 200 engravings. By SAMUEL SLOAN, Architect. 8vo. $2.50

SLOANE.—Home Experiments in Science.
By T. O'CONOR SLOANE, E. M., A. M., Ph. D. Illustrated by 91 engravings. 12mo. $1.00

SMEATON.—Builder's Pocket-Companion:
Containing the Elements of Building, Surveying, and Architecture; with Practical Rules and Instructions connected with the subject. By A. C. SMEATON, Civil Engineer, etc. 12mo.

SMITH.—A Manual of Political Economy.
By E. PESHINE SMITH. A New Edition, to which is added a full Index. 12mo. $1.25

SMITH.—Parks and Pleasure-Grounds:

Or Practical Notes on Country Residences, Villas, Public Parks, and Gardens. By CHARLES H. J. SMITH, Landscape Gardener and Garden Architect, etc., etc. 12mo. $2.00

SMITH.—The Dyer's Instructor:

Comprising Practical Instructions in the Art of Dyeing Silk, Cotton, Wool, and Worsted, and Woolen Goods; containing nearly 800 Receipts. To which is added a Treatise on the Art of Padding; and the Printing of Silk Warps, Skeins, and Handkerchiefs, and the various Mordants and Colors for the different styles of such work. By DAVID SMITH, Pattern Dyer. 12mo. $1.50

SMYTH.—A Rudimentary Treatise on Coal and Coal-Mining.

By WARRINGTON W. SMYTH, M. A., F. R. G., President R. G. S. of Cornwall. Fifth edition, revised and corrected. With numerous illustrations. 12mo. $1.40

SNIVELY.—Tables for Systematic Qualitative Chemical Analysis.

By JOHN H. SNIVELY, Phr. D. 8vo. $1.00

SNIVELY.—The Elements of Systematic Qualitative Chemical Analysis:

A Hand-book for Beginners. By JOHN H. SNIVELY, Phr. D. 16mo. $2.00

STOKES.—The Cabinet-Maker and Upholsterer's Companion:

Comprising the Art of Drawing, as applicable to Cabinet Work; Veneering, Inlaying, and Buhl-Work; the Art of Dyeing and Staining Wood, Ivory, Bone, Tortoise-Shell, etc. Directions for Lackering, Japanning, and Varnishing; to make French Polish, Glues, Cements, and Compositions; with numerous Receipts, useful to workmen generally. By STOKES. Illustrated. A New Edition, with an Appendix upon French Polishing, Staining, Imitating, Varnishing, etc., etc. 12mo $1.25

STRENGTH AND OTHER PROPERTIES OF METALS:

Reports of Experiments on the Strength and other Properties of Metals for Cannon. With a Description of the Machines for Testing Metals, and of the Classification of Cannon in service. By Officers of the Ordnance Department, U. S. Army. By authority of the Secretary of War. Illustrated by 25 large steel plates. Quarto . $5.00

SULLIVAN.—Protection to Native Industry.

By Sir EDWARD SULLIVAN, Baronet, author of "Ten Chapters on Social Reforms." 8vo. $1.00

SHERRATT.—The Elements of Hand-Railing:

Simplified and Explained in Concise Problems that are Easily Understood. The whole illustrated with Thirty-eight Accurate and Original Plates, Founded on Geometrical Principles, and Showing how to Make Rail Without Centre Joints, Making Better Rail of the Same Material, with Half the Labor, and Showing How to Lay Out Stairs of all Kinds. By R. J. SHERRATT. Folio. . . . $2.50

SYME.—Outlines of an Industrial Science.
By DAVID SYME. 12mo. $2.00

TABLES SHOWING THE WEIGHT OF ROUND, SQUARE, AND FLAT BAR IRON, STEEL, ETC.,
By Measurement. Cloth 63

THALLNER.—Tool-Steel:
A Concise Handbook on Tool-Steel in General. Its Treatment in the Operations of Forging, Annealing, Hardening, Tempering, etc., and the Appliances Therefor. By OTTO THALLNER, Manager in Chief of the Tool-Steel Works, Bismarckhütte, Germany. From the German by WILLIAM T. BRANNT. Illustrated by 69 engravings. 194 pages. 8vo. 1902. . . . . $2.00

TEMPLETON.—The Practical Examinator on Steam and the Steam-Engine:
With Instructive References relative thereto, arranged for the Use of Engineers, Students, and others. By WILLIAM TEMPLETON, Engineer. 12mo. $1.00

THAUSING.—The Theory and Practice of the Preparation of Malt and the Fabrication of Beer:
With especial reference to the Vienna Process of Brewing. Elaborated from personal experience by JULIUS E. THAUSING, Professor at the School for Brewers, and at the Agricultural Institute, Mödling, near Vienna. Translated from the German by WILLIAM T. BRANNT. Thoroughly and elaborately edited, with much American matter, and according to the latest and most Scientific Practice, by A. SCHWARZ and DR. A. H. BAUER. Illustrated by 140 Engravings. 8vo., 815 pages $10.00

THOMPSON.—Political Economy. With Especial Reference to the Industrial History of Nations:
By ROBERT E. THOMPSON, M. A., Professor of Social Science in the University of Pennsylvania. 12mo. $1.50

THOMSON.—Freight Charges Calculator:
By ANDREW THOMSON, Freight Agent. 24mo. . . . $1.25

TURNER'S (THE) COMPANION:
Containing Instructions in Concentric, Elliptic, and Eccentric Turning; also various Plates of Chucks, Tools, and Instruments; and Directions for using the Eccentric Cutter, Drill, Vertical Cutter, and Circular Rest; with Patterns and Instructions for working them. 12mo. $1.00

TURNING: Specimens of Fancy Turning Executed on the Hand or Foot-Lathe:
With Geometric, Oval, and Eccentric Chucks, and Elliptical Cutting Frame. By an Amateur. Illustrated by 30 exquisite Photographs. 4to. . . . . (Scarce.)

VAILE.—Galvanized-Iron Cornice-Worker's Manual:
Containing Instructions in Laying out the Different Mitres, and Making Patterns for all kinds of Plain and Circular Work. Also, Tables of Weights, Areas and Circumferences of Circles, and other Matter calculated to Benefit the Trade. By CHARLES A. VAILE. Illustrated by twenty-one plates. 4to. . . . . . (Scarce.)

VILLE.—On Artificial Manures:
Their Chemical Selection and Scientific Application to Agriculture. A series of Lectures given at the Experimental Farm at Vincennes, during 1867 and 1874–75. By M. GEORGES VILLE. Translated and Edited by WILLIAM CROOKES, F. R. S. Illustrated by thirty-one engravings. 8vo., 450 pages $6.00

VILLE.—The School of Chemical Manures:
Or, Elementary Principles in the Use of Fertilizing Agents. From the French of M. GEO. VILLE, by A. A. FESQUET, Chemist and Engineer. With Illustrations. 12mo. $1.25

VOGDES.—The Architect's and Builder's Pocket-Companion and Price-Book:
Consisting of a Short but Comprehensive Epitome of Decimals, Duodecimals, Geometry and Mensuration; with Tables of United States Measures, Sizes, Weights, Strengths, etc., of Iron, Wood, Stone, Brick, Cement and Concretes, Quantities of Materials in given Sizes and Dimensions of Wood, Brick and Stone; and full and complete Bills of Prices for Carpenter's Work and Painting; also, Rules for Computing and Valuing Brick and Brick Work, Stone Work, Painting, Plastering, with a Vocabulary of Technical Terms, etc. By FRANK W. VOGDES, Architect, Indianapolis, Ind. Enlarged, revised, and corrected. In one volume, 368 pages, full-bound, pocket-book form, gilt edges $2.00
Cloth 1.50

VAN CLEVE.—The English and American Mechanic:
Comprising a Collection of Over Three Thousand Receipts, Rules, and Tables, designed for the Use of every Mechanic and Manufacturer. By B. FRANK VAN CLEVE. Illustrated. 500 pp. 12mo. $2.00

VAN DER BURG.—School of Painting for the Imitation of Woods and Marbles:
A Complete, Practical Treatise on the Art and Craft of Graining and Marbling with the Tools and Appliances. 36 plates. Folio, 12 x 20 inches. $10.00

WAHNSCHAFFE.—A Guide to the Scientific Examination of Soils:
Comprising Select Methods of Mechanical and Chemical Analysis and Physical Investigation. Translated from the German of Dr. F. WAHNSCHAFFE. With additions by WILLIAM T. BRANNT. Illustrated by 25 engravings. 12mo. 177 pages $1.50

WALTON.—Coal-Mining Described and Illustrated:
By THOMAS H. WALTON, Mining Engineer. Illustrated by 24 large and elaborate Plates, after Actual Workings and Apparatus. $5.00

WARE.—The Sugar Beet.

Including a History of the Beet Sugar Industry in Europe, Varieties of the Sugar Beet, Examination, Soils, Tillage, Seeds and Sowing, Yield and Cost of Cultivation, Harvesting, Transportation, Conservation, Feeding Qualities of the Beet and of the Pulp, etc. By LEWIS S. WARE, C. E., M. E. Illustrated by ninety engravings. 8vo. $4.00

WARN.—The Sheet-Metal Worker's Instructor:

For Zinc, Sheet-Iron, Copper, and Tin-Plate Workers, etc. Containing a selection of Geometrical Problems; also, Practical and Simple Rules for Describing the various Patterns required in the different branches of the above Trades. By REUBEN H. WARN, Practical Tin-Plate Worker. To which is added an Appendix, containing Instructions for Boiler-Making, Mensuration of Surfaces and Solids, Rules for Calculating the Weights of different Figures of Iron and Steel, Tables of the Weights of Iron, Steel, etc. Illustrated by thirty-two Plates and thirty-seven Wood Engravings. 8vo. . $3.00

WARNER.—New Theorems, Tables, and Diagrams, for the Computation of Earth-work:

Designed for the use of Engineers in Preliminary and Final Estimates, of Students in Engineering, and of Contractors and other non-professional Computers. In two parts, with an Appendix. Part I. A Practical Treatise; Part II. A Theoretical Treatise, and the Appendix. Containing Notes to the Rules and Examples of Part I.; Explanations of the Construction of Scales, Tables, and Diagrams, and a Treatise upon Equivalent Square Bases and Equivalent Level Heights By JOHN WARNER, A. M., Mining and Mechanical Engineer. Illustrated by 14 Plates. 8vo. $3.00

WILSON.—Carpentry and Joinery:

By JOHN WILSON, Lecturer on Building Construction, Carpentry and Joinery, etc., in the Manchester Technical School. Third Edition, with 65 full-page plates, in flexible cover, oblong. . . (Scarce.)

WATSON.—A Manual of the Hand-Lathe:

Comprising Concise Directions for Working Metals of all kinds, Ivory, Bone, and Precious Woods; Dyeing, Coloring, and French Polishing; Inlaying by Veneers, and various methods practised to produce Elaborate work with Dispatch, and at Small Expense. By EGBERT P. WATSON, Author of "The Modern Practice of American Machinists and Engineers." Illustrated by 78 engravings. $1.50

WATSON.—The Modern Practice of American Machinists and Engineers:

Including the Construction, Application, and Use of Drills, Lathe Tools, Cutters for Boring Cylinders, and Hollow-work generally, with the most Economical Speed for the same; the Results verified by Actual Practice at the Lathe, the Vise, and on the floor. Together

with Workshop Management, Economy of Manufacture, the Steam Engine, Boilers, Gears, Belting, etc., etc. By EGBERT P. WATSON. Illustrated by eighty-six engravings. 12mo. $2.50

WATT.—The Art of Soap Making:

A Practical Hand-Book of the Manufacture of Hard and Soft Soaps, Toilet Soaps, etc. Fifth Edition, Revised, to which is added an Appendix on Modern Candle Making. By ALEXANDER WATT. Ill. 12mo. $3.00

WEATHERLY.—Treatise on the Art of Boiling Sugar, Crystallizing, Lozenge-making, Comfits, Gum Goods,

And other processes for Confectionery, including Methods for Manufacturing every Description of Raw and Refined Sugar Goods. A New and Enlarged Edition, with an Appendix on Cocoa, Chocolate, Chocolate Confections, etc. 196 pages, 12mo. (1903) . $1.50

WILL.—Tables of Qualitative Chemical Analysis:

With an Introductory Chapter on the Course of Analysis. By Professor HEINRICH WILL, of Giessen, Germany. Third American, from the eleventh German edition. Edited by CHARLES F. HIMES, Ph. D., Professor of Natural Science, Dickinson College, Carlisle, Pa. 8vo. $1.50

WILLIAMS.—On Heat and Steam:

Embracing New Views of Vaporization, Condensation and Explosion. By CHARLES WYE WILLIAMS, A. I. C. E. Illustrated. 8vo. $2.50

WILSON.—First Principles of Political Economy:

With Reference to Statesmanship and the Progress of Civilization. By Professor W. D. WILSON, of the Cornell University. A new and revised edition. 12mo. $1.50

WILSON.—The Practical Tool-Maker and Designer:

A Treatise upon the Designing of Tools and Fixtures for Machine Tools and Metal Working Machinery, Comprising Modern Examples of Machines with Fundamental Designs for Tools for the Actual Production of the work; Together with Special Reference to a Set of Tools for Machining the Various Parts of a Bicycle. Illustrated by 189 engravings. 1898. . . . . $2.50

CONTENTS: Introductory. Chapter I. Modern Tool Room and Equipment. II. Files, Their Use and Abuse. III. Steel and Tempering. IV. Making Jigs. V. Milling Machine Fixtures. VI. Tools and Fixtures for Screw Machines. VII. Broaching. VIII. Punches and Dies for Cutting and Drop Press. IX. Tools for Hollow-Ware. X. Embossing: Metal, Coin, and Stamped Sheet-Metal Ornaments. XI. Drop Forging. XII. Solid Drawn Shells or Ferrules; Cupping or Cutting, and Drawing; Breaking Down Shells. XIII. Annealing, Pickling, and Cleaning, XIV. Tools for Draw Bench. XV. Cutting and Assembling Pieces by Means of Ratchet Dial Plates at One Operation. XVI. The Header. XVII. Tools for Fox Lathe. XVIII. Suggestions for a Set of Tools for Machining the Various Parts of a Bicycle. XIX. The Plater's Dynamo. XX. Conclusion—With a Few Random Ideas. Appendix. Index.

WOODS.—Compound Locomotives:

By ARTHUR TANNATT WOODS. Second edition, revised and enlarged by DAVID LEONARD BARNES, A. M., C. E. 8vo. 330 pp. $3.00

WOHLER.—A Hand-Book of Mineral Analysis:

By F. WÖHLER, Professor of Chemistry in the University of Göttingen. Edited by HENRY B. NASON, Professor of Chemistry in the Renssalaer Polytechnic Institute, Troy, New York. Illustrated. 12mo. $2.50

WORSSAM.—On Mechanical Saws:

From the Transactions of the Society of Engineers, 1869. By S. W. WORSSAM, JR. Illustrated by eighteen large plates. 8vo. $1.50

RECENT ADDITIONS.

BRANNT.—Varnishes, Lacquers, Printing Inks and Sealing-Waxes:

Their Raw Materials and their Manufacture, to which is added the Art of Varnishing and Lacquering, including the Preparation of Putties and of Stains for Wood, Ivory, Bone, Horn, and Leather. By WILLIAM T. BRANNT. Illustrated by 39 Engravings, 338 pages. 12mo. $3.00

BRANNT—The Practical Scourer and Garment Dyer:

Comprising Dry or Chemical Cleaning; the Art of Removing Stains; Fine Washing; Bleaching and Dyeing of Straw Hats, Gloves, and Feathers of all kinds; Dyeing of Worn Clothes of all fabrics, including Mixed Goods, by One Dip; and the Manufacture of Soaps and Fluids for Cleansing Purposes. Edited by WILLIAM T. BRANNT, Editor of "The Techno-Chemical Receipt Book." Illustrated. 203 pages. 12mo. $2.00

BRANNT.—Petroleum.

Its History, Origin, Occurrence, Production, Physical and Chemical Constitution, Technology, Examination and Uses; Together with the Occurrenee and Uses of Natural Gas. Edited chiefly from the German of Prof. Hans Hoefer and Dr. Alexander Veith, by WM. T. BRANNT. Illustrated by 3 Plates and 284 Engravings. 743 pp. 8vo. $7.50

BRANNT.—A Practical Treatise on the Manufacture of Vinegar and Acetates, Cider, and Fruit-Wines:

Preservation of Fruits and Vegetables by Canning and Evaporation; Preparation of Fruit-Butters, Jellies, Marmalades, Catchups, Pickles, Mustards, etc. Edited from various sources. By WILLIAM T. BRANNT. Illustrated by 79 Engravings. 479 pp. 8vo. $5.00

BRANNT.—The Metal Worker's Handy-Book of Receipts and Processes:

Being a Collection of Chemical Formulas and Practical Manipulations for the working of all Metals; including the Decoration and Beautifying of Articles Manufactured therefrom, as well as their Preservation. Edited from various sources. By WILLIAM T. BRANNT. Illustrated. 12mo. $2.50

DEITE.—A Practical Treatise on the Manufacture of Perfumery:
Comprising directions for making all kinds of Perfumes, Sachet Powders, Fumigating Materials, Dentifrices, Cosmetics, etc., with a full account of the Volatile Oils, Balsams, Resins, and other Natural and Artificial Perfume-substances, including the Manufacture of Fruit Ethers, and tests of their purity. By Dr. C. DEITE, assisted by L. BORCHERT, F. EICHBAUM, E. KUGLER, H. TOEFFNER, and other experts. From the German, by WM. T. BRANNT. 28 Engravings. 358 pages. 8vo. $3.00

EDWARDS.—American Marine Engineer, Theoretical and Practical:
With Examples of the latest and most approved American Practice. By EMORY EDWARDS. 85 illustrations. 12mo. . . . $2.50

EDWARDS.—900 Examination Questions and Answers:
For Engineers and Firemen (Land and Marine) who desire to obtain a United States Government or State License. Pocket-book form, gilt edge $1.50

FLEMMING.—Practical Tanning:
A Handbook of Modern Processes, Receipts, and Suggestions for the Treatment of Hides, Skins, and Pelts of Every Description. By Lewis A. Flemming. American Tanner. 472 pp. 8vo. (1903) $4.00.

POSSELT.—The Jacquard Machine Analysed and Explained:
With an Appendix on the Preparation of Jacquard Cards, and Practical Hints to Learners of Jacquard Designing. By E. A. POSSELT. With 230 illustrations and numerous diagrams. 127 pp. 4to. $3.00

POSSELT.—Recent Improvements in Textile Machinery, Part III:
Processes Required for Converting Wool, Cotton, Silk, from Fibre to Finished Fabric, Covering both Woven and Knit Goods; Construction of the most Modern Improvements in Preparatory Machinery, Carding, Combing, Drawing, and Spinning Machinery, Winding, Warping, Slashing Machinery Looms, Machinery for Knit Goods, Dye Stuffs, Chemicals, Soaps, Latest Improved Accessories Relating to Construction and Equipment of Modern Textile Manufacturing Plants. By E. A. POSSELT. Completely Illustrated. 4to. $7.50

RICH.—Artistic Horse-Shoeing:
A Practical and Scientific Treatise, giving Improved Methods of Shoeing, with Special Directions for Shaping Shoes to Cure Different Diseases of the Foot, and for the Correction of Faulty Action in Trotters. By GEORGE E. RICH. 62 Illustrations. 153 pages. 12mo $1.00

RICHARDSON.—Practical Blacksmithing:

A Collection of Articles Contributed at Different Times by Skilled Workmen to the columns of "The Blacksmith and Wheelwright," and Covering nearly the Whole Range of Blacksmithing, from the Simplest Job of Work to some of the Most Complex Forgings. Compiled and Edited by M. T. RICHARDSON.

Vol. I. 210 Illustrations. 224 pages. 12mo. . . $1.00
Vol. II. 230 Illustrations. 262 pages. 12mo. . . $1.00
Vol. III. 390 Illustrations. 307 pages. 12mo. . . $1.00
Vol. IV. 226 Illustrations. 276 pages. 12mo. . . $1.00

RICHARDSON.—The Practical Horseshoer:

Being a Collection of Articles on Horseshoeing in all its Branches which have appeared from time to time in the columns of "The Blacksmith and Wheelwright," etc. Compiled and edited by M. T. RICHARDSON. 174 illustrations. $1.00

ROPER.—Instructions and Suggestions for Engineers and Firemen:

By STEPHEN ROPER, Engineer. 18mo. Morocco . $2.00

ROPER.—The Steam Boiler: Its Care and Management:

By STEPHEN ROPER, Engineer. 12mo., tuck, gilt edges. $2.00

ROPER.—The Young Engineer's Own Book:

Containing an Explanation of the Principle and Theories on which the Steam Engine as a Prime Mover is Based. By STEPHEN ROPER, Engineer. 160 illustrations, 363 pages. 18mo., tuck . $2.50

ROSE.—Modern Steam-Engines:

An Elementary Treatise upon the Steam-Engine, written in Plain language; for Use in the Workshop as well as in the Drawing Office. Giving Full Explanations of the Construction of Modern Steam-Engines: Including Diagrams showing their Actual operation. Together with Complete but Simple Explanations of the operations of Various Kinds of Valves, Valve Motions, and Link Motions, etc., thereby Enabling the Ordinary Engineer to clearly Understand the Principles Involved in their Construction and Use, and to Plot out their Movements upon the Drawing Board. By JOSHUA ROSE, M. E. Illustrated by 422 engravings. Revised. 358 pp. . . $6.00

ROSE.—Steam Boilers:

A Practical Treatise on Boiler Construction and Examination, for the Use of Practical Boiler Makers, Boiler Users, and Inspectors; and embracing in plain figures all the calculations necessary in Designing or Classifying Steam Boilers. By JOSHUA ROSE, M. E. Illustrated by 73 engravings. 250 pages. 8vo. $2.50

SCHRIBER.—The Complete Carriage and Wagon Painter:

A Concise Compendium of the Art of Painting Carriages, Wagons, and Sleighs, embracing Full Directions in all the Various Branches, including Lettering, Scrolling, Ornamenting, Striping, Varnishing, and Coloring, with numerous Recipes for Mixing Colors. 73 Illustrations. 177 pp. 12mo. $1.00